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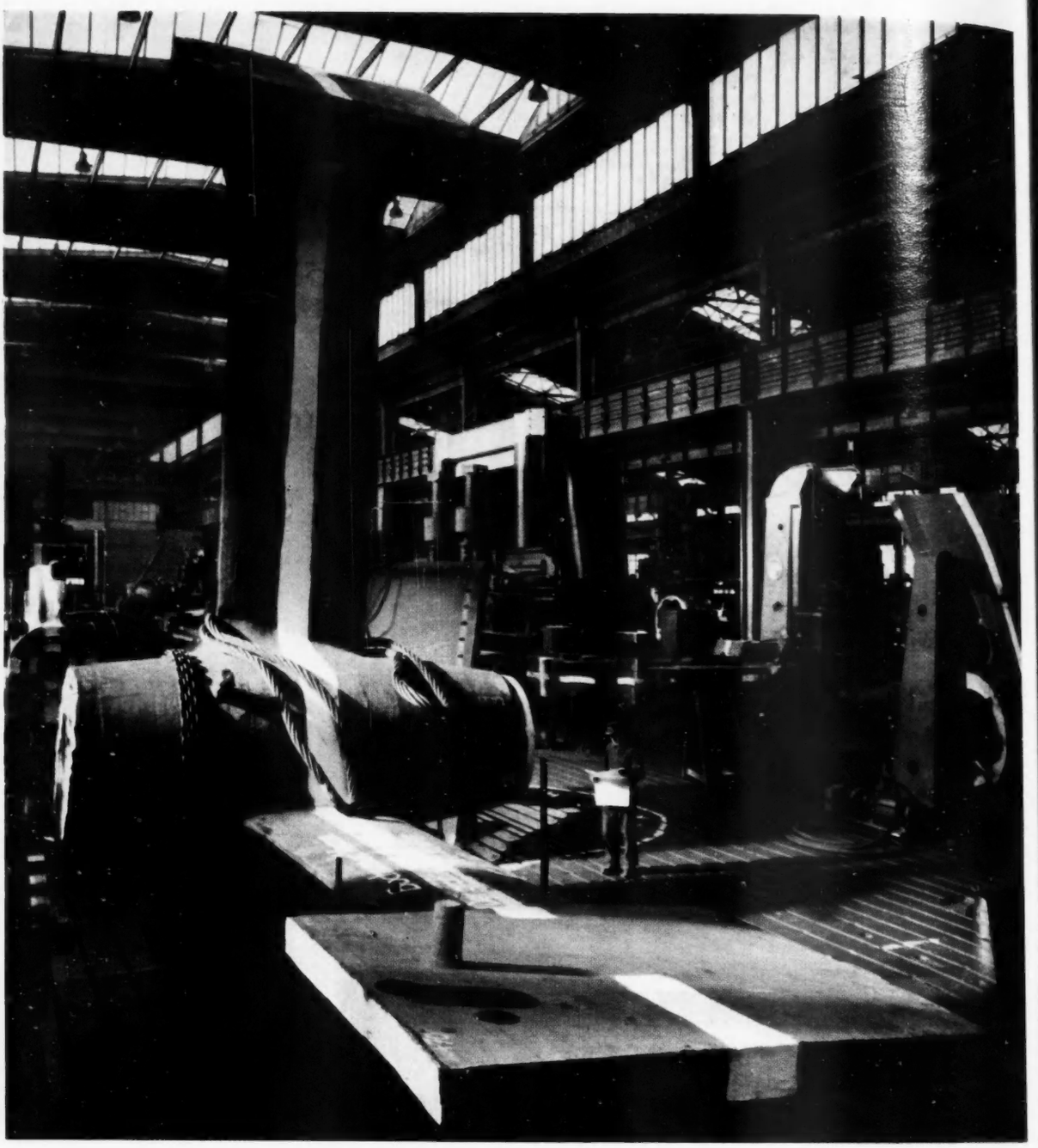

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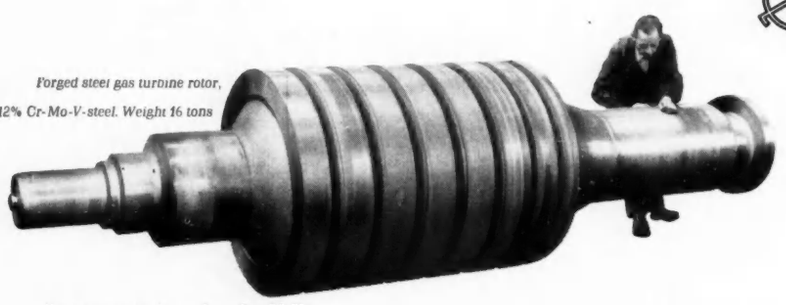

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ENGINEERING *Appointments Section faces page 580*

Who Cracks the Whip?

A FACTORY building used to be an empty shell. Now it may be designed for one industrial process; and machines, services, and structure are an integrated unit. The factory is becoming a new order of machine.

The conception of an industrial building involves many specialist engineers. Yet, as it is more than a machine, with parts not wholly mechanical, a factory's fitness for purpose cannot be measured by engineering standards alone.

There are other requirements. One of them is aesthetic; how it is embodied is discussed on page 576, and there it can be seen how an architect, starting from this slender toe-hold, climbs to a commanding position in a building project. Because the engineer does not study beauty, the architect becomes the king pin, forming a link between the team of engineers who require a new factory and the team of engineers who can build it. He may recognise the engineer as an indispensable adviser, but he, the architect, cracks the whip.

It is true that the architect is not always in charge. Sometimes the engineer designs and builds, with the architect as consultant. But the fact that the architect can achieve a managerial position in engineering is worth considering.

Just as the increased complexity of industrial operations has led to larger and more complicated factory buildings, so has it led to analogous development in other fields. This has given rise to studies such as operations research, systems analysis, and control systems engineering, which in their broad outlines have certain features in common with industrial architecture: the situations they treat are complex, their solutions are the result of optimising the effect of a large number of variables, and they are generally tackled by a team of specialists. Coordination is the keynote. Control systems engineering, because of its more modest scope, is organisationally simpler than the others, but like them it cuts across the divisions of engineering.

In fact the common characteristic of these studies is the way they stand in relation to the conventional divisions of engineering. They are not further variations of the established trio—civil, mechanical, and electrical. They are of a different order.

The moral for the engineer is that just as the architect has taken the trouble to learn some engineering, and so been able to take the lead in factory construction, so may other non-engineers play major parts in these new studies. And if this happens the engineer must accept a secondary position in industrial operations.

Even in the making of engineering equipment, a new "architect" is struggling for birth: the appearance designer. The topic is taken up in this month's issue of the *Journal* of the Institution of Electrical Engineers. In it, Mr. T. B. Dunne makes the, point that "The work of the appearance designer can have a far-reaching effect on the use and operation of electrical equipment..." He concludes: "There is something to be said for engineering apprentices being given a good grounding in the subject during their training." The operative phrase is "good grounding." What is becoming increasingly necessary in engineering courses is a basic discussion of the impact of engineering on the life of the country. Two important aspects of engineering products—ease of use, and pleasing appearance—are not considered at all in many engineering courses. An engineer should emerge from his basic training with some idea of what beauty and utility are; it should certainly not be necessary to introduce Mr. Dunne with, "The author of this article is bold enough to discuss the probable existence of abiding principles of appearance design."

As far as the other studies are concerned, their cooperative nature and the emphasis they put on a careful study of the way complex problems should be approached shows that they cannot be treated as just another topic to be squeezed into the engineering syllabus. They are of a higher order of complexity, as the factory is to the machine. Their intimate connection with the realities of industrial life, with the give and take of different disciplines, strongly suggests that after an engineering degree has been taken, life in industry should be experienced before such coordinating disciplines are studied.

Such a "sandwich" course would be much longer than the present conventional engineering courses, which are nearly all arranged in such a way that the intellectually bright become specialists automatically. But the example of the architect is before us. It shows the rewards obtained by being willing to extend one's knowledge to other fields; it stands as a warning to the specialist. The late Frank Lloyd Wright once said that very few architects know anything about architecture. He added "For 500 years architecture has been phoney." Let us also remember his description of the expert: "An expert is a man who has stopped thinking. Why should he think? He is an expert."

Cover Picture.—*Control room for PLUTO, the materials and engineering test reactor at Harwell. The reactor is similar in many respects to its predecessor DIDO and, like it, is cooled and moderated by heavy water.*

(*Nurnberg photograph for* ENGINEERING)

Plain Words

A committee of the Engineers Guild have been investigating " the extent to which professional engineers are required to clock in at their place of work, the ways in which such a system is operated, and the justification claimed for it."

There was a time, when I was an apprentice, when I didn't mind the clocking in so much as the getting up early. On a winter morning it could be very dreary, trudging through the smoky, damp works. All the romance of engineering had disappeared then and I longed for summer days when I might be lucky and go out with a fitter to an outside job. If I arrived a few minutes late on one of those dismal mornings, there was nothing I could do about it—the card was an indisputable record of my laziness. (Didn't the ink change to red the second you were late?)

But once or twice I actually forgot to clock in although I had arrived in good time. It wasn't until half past twelve, when I came to clock out, that I discovered my omission; my card was on the wrong board. The only thing to do then was to go and see one of the clerks in the shop office—and ask him to set it right. He was a delightful, elderly character, a quiet philosophic man in marked contrast to most of the men on the shop floor. He was so pleasant about the incident that I was always glad of an excuse to go and talk to him. Among his duties was the making up of the pay packets (actually little tins, each with the man's number on its lid), and as there were nearly a thousand men in the shop there was a tidy sum to be sorted.

If I were asked to clock in now, I would ask for a special pocket clock—one that I could surreptitiously start and stop when my wife was talking to me and I was thinking about the office instead of listening to her. This little clock would have to show, too, that when the card recorded, say, 12.05 to 12.30 the time was not necessarily in the afternoon, but might be just after midnight.

I agree with the committee's conclusions. They say that " recording the attendance of staff by some means is a matter of administrative convenience and that it may in certain cases be necessary. Nevertheless, as has been stated in regard to payment for overtime, the policy of the Guild is that the professional engineer's hours of work are determined by the requirements of his job and not by the clock . . ." They go on to say that any attempt to require him to clock in should be opposed.

The committee found, however, that in some cases the managing director is required to sign a book or punch a clock on arrival each day. It would not be easy to argue about clocking in with that breed of managing director.

CAPRICORN

Weekly Survey

Supersonics or Bread and Butter

The supersonic airliner committee's recommendations, announced recently by the Minister of Supply, provided a natural " Aunt Sally " for the annual conference on " Problems of Aircraft Production " held by the Institution of Production Engineers at Southampton later that week. The committee recommended that detailed design work should be carried out on two projects—a 100 passenger aircraft to cruise at Mach 1·2 (about 800 m.p.h.) for stages up to 1,500 miles, and a 150 passenger Mach 1·8 (1,300 m.p.h.) trans-oceanic airliner for the non-stop North Atlantic run (see Companies in the News, page 536, last week). These recommendations were described by Mr. Peter Masefield, managing director of Bristol Aircraft Limited, as " commercial nonsense."

In the United States the Convair B58 bomber has already built up hours of Mach 2 cruising experience, and next year the North American B70 bomber will be in the air cruising at Mach 3. Against this background all the big American aircraft constructors are confident that they could produce a Mach 3 airliner for commercial service by 1970—by which time (and not before) the airlines may be able to afford to order new aircraft. It is unlikely, then, that BOAC or any operator will be interested in an aircraft designed to cruise at only 1,300 m.p.h. when competing American airliners capable of 2,000 m.p.h. will be available.

The Mach 3 aircraft—essentially a rather large machine—will be able to cross the Atlantic in only 2½ hours. For this reason, the whole of today's trans-atlantic traffic, Mr. Masefield estimates, could be handled by only four Mach 3 airliners; and, he suggested, the commercial market cannot possibly exceed about 10 such aircraft—at a development and production cost totalling some £300 million, but employing comparatively few productive workers.

There is little doubt, however, that the Americans will go ahead with the Mach 3 airliner. Britain, then, has to decide whether to remain in the " big league," as Mr. Masefield describes it, and compete with America and Russia in this costly technical race However, it seem generally accepted that air transport is likely to develop along two parallel lines in future—the high-speed high-fare category and the moderate-speed low-fare market. If the country has to choose between prestige and bread-and-butter, then Mr. Masefield, together with Lord Douglas of British European Airways, would go for " bread and butter "—the development of a really economical aircraft that would cut fares to half their present values and which could be built in profitably large numbers, thus keeping in employment some of the 100,000 skilled workers who otherwise may have to be turned adrift during the next two or three years.

Twice Times Whitworth

It is a sign of the times that the value of the Whitworth Fellowship, still recognised as the highest award among engineering exhibitions, is to be doubled. Its value will be raised from £500 to £1,000 a year from 1960. Inflation and the country's educational policy of spending increasing amounts on technical education have together forced the Minister of Education to make this substantial financial adjustment. The Minister is the trustee of the Sir Joseph Whitworth Foundation. Up to three Whitworth fellowships tenable for 2 years are offered annually as well as 6 prizes of £50 each awarded to unsuccessful fellowship candidates whose work deserves recognition. These last will go up to £100 each.

An important modification has also been made to the rules. Until now, the awards have been made to newly qualified engineers. In future they will go to practising engineers who have shown themselves likely to benefit from further study and training. Applicants must be over 25 years, with an engineering degree, a Diploma in Technology (engineering), a Higher National Diploma or a Higher National Certificate in engineering with at least two distinctions. They must have been practising engineers for at least 3 years.

The purpose of the award has thus shifted significantly. It has been felt for a long time that provision should be made for the outstanding young man who has achieved a high level of competence at graduate level (or its equivalent) and whose ideas on research have crystallised against a practical background for several years.

Locked up Stress in Planning

At no point is the clash of priorities on economic and social development more apparent than in town planning. In the last year or so, the difficulty of relating industrial efficiency to the development of new towns has been underlined by the belated but now rapid development of plans for reducing congestion in the Glasgow area. The 1959 annual report of the Town and Country Planning Association published last week, has also come back to the subject in urging that town and country planning should play a bigger part in economic planning.

The problem is a difficult one and completely bedevilled by the fact that all concerned are to a large extent prisoners of the past. Low standards of housing in some areas and a growth of population of a further 3·5 million by 1978 demand a radical approach to new housing areas which will not add to existing conurbations. On the other hand, an overweening urge to build new houses in the last decade or more has diverted housing materials from older buildings and encouraged the growth of slums.

Ugly and congested as many conurbations are, they are often large markets and near good sea communications. They are low cost areas for industry and in a haphazard sort of way have built up more industrial balance in their agglomoration of factories and offices than they get credit for. They are politically powerful (being congested) and those who would cream off light industries to new towns must face the fact that the large, older towns have something of a vested interest in seeing that this process does not go too far. Putting town planning and economic planning in too close harness might see the latter try to swallow the former if some interests had their way.

Seaway Benefits for Britain

The St. Lawrence Seaway came into use last week and brings new opportunities for British shipping and exporters to the North American continent. The project was initiated by shipping interests on the Great Lakes and was largely carried through by them in face of considerable opposition from the Atlantic ports and railways in Canada and from the United States, primarily to permit carriage of grain to terminals in the St. Lawrence Gulf and the return of ores from Quebec. The Canadian Government has, however, decided to allow British ships to take part in the traffic, and through rates to Toronto quoted by the Canada North Atlantic Westbound Freight Conference suggest that British shipowners intend to compete in the packaged goods trade to the Great Lakes ports. These rates

should also assist British manufacturers exporting to the territories bordering the Lakes.

By 1 June next, the Seaway will provide a depth of 27 ft along the 180 miles of the St. Lawrence River between Montreal and Lake Ontario and by 1961 this depth will be extended to the Lake ports. This is expected to permit ocean going ships carrying up to 9,000 tons of cargo to reach the Lake ports while Lake ships carrying up to 25,000 tons of grain will be able to reach Montreal and the lower St. Lawrence.

Ocean going vessels intending to take part in Lake traffic will need a number of modications including the provision of stern anchors to combat the St. Lawrence currents while waiting to pass through the locks, and of septic tanks since sewage cannot be discharged into the Lakes. There are also a number of economic uncertainties including the level of toll and pilotage charges and the risk that unforeseen delays might result in a vessel being imprisoned in the Lakes through the winter due to freezing of the St. Lawrence.

Canada and the United States are to issue international postage stamps to commemorate the official opening of the Seaway on 26 June by Queen Elizabeth and President Eisenhower.

Impulse from the Railways

Attention has been drawn by Sir Brian Robertson, chairman of the British Transport Commission, to the growing association between British Railways and the electrical engineering industry as the main emphasis of the railway modernisation programme shifts to electrification. Sir Brian was speaking at the annual dinner and reunion of the Association of Supervising Electrical Engineers, where he proposed the toast of the electrical industry and the association. In his reply, Mr. S. E. Goodall, president of the Institution of Electrical Engineers, said that British Railways were becoming one of the largest customers of the electrical engineering industry.

Sir Brian referred to the completion this year of the electrification of the Kent Coast lines, while the Clacton and Styal lines are already providing experience of operation at 25 kV a.c. Technical problems arising from the use of this new system are being overcome and from now on priority will be given to the Midland Region routes to Birmingham and Manchester.

As regards the impact on electrical engineers, Sir Brian thought that the scheme should be of considerable help to the electrical engineering industry since the experience gained should help the industry to expand exports of electrical railway equipment, as has already been the case in France. The electricity supply industry will also be concerned because peak hour traffic will affect the pattern of electricity consumption.

Sir Brian said that he was still not happy about the speed at which electrification was being carried out. He referred to the suggestions that all the work for a particular scheme should be allocated to a single company, but thought that this would be impracticable owing to the need to maintain continuity of services during the change-over period.

Proposals for Euratom Plants

The joint power reactor programme agreed under the United States-Euratom Cooperation Agreement moves a step towards full implementation with the publication of a notice inviting proposals for projects under the agreement. The main requirement of any projected reactor is that it will be able to come into operation before the end of 1963. The other criteria are as follows. The expected price of the electric power produced must be as near as possible to the competitive price of power from traditional sources. The power station must be designed to allow scope for further development. Preference will be given to projects which are able to make use of funds, materials and services available under the agreement. Lastly, the projects should contribute to promoting and making competitive the nuclear equipment industry in the Euratom Community and the United States.

A number of other considerations will be taken into account by the Euratom authorities. One will be to arrange a reasonable geographical spread of nuclear power projects within the six member nations. Another factor is that all power stations will be built and operated by firms in the Community, and will remain their property. Euratom will, however, own and control the fissile materials used in the programme. The firms selected to carry out the projects will be given financial help, a guaranteed supply of fuel, and a guaranteed market for the plutonium they produce. In order to help the nuclear industries of the Community and the United States all knowledge gained under the programme must be made immediately available. The type of reactors under the programme will be for power stations with a capacity of 150 MW or over. Projects, according to the *Journal Officiel* of the European Communities can be submitted up to 1 September, 1959.

Deep Sea Mining

Interest has recently been aroused in the possibility of extracting large quantities of manganese, nickel, cobalt and copper from the sea bed. Deep sea dredging carried out by the Scripps Institution of Oceanography of La Jolla, California, during the International Geophysical Year brought to light quantities of nodules of these metals. Similar nodules had been discovered in various parts of the world's oceans as long ago as 1876 during the scientific survey carried out by HMS Challenger and also some 25 years later by a United States vessel. Owing to the great technical difficulties of recovering such deposits from the sea, the possibility had been largely forgotten.

Apart from the great technical difficulties to be overcome, there is also of course the question of markets. The nodules so far reported contain about 20 per cent manganese, and cobalt, nickel, and copper in quantities less than 2 per cent. The work so far done suggests that the manganese at present market prices would not be worth exploiting, but that the cobalt and nickel would be valuable.

The United Kingdom might be expected to show an interest in any sources of manganese in view of its reliance on foreign sources of supply.

Looking for Persephone ?

A project to drill a hole through the earth's crust has been announced by the National Academy of Sciences in New York. A group of American research ships will assemble in the Atlantic north of Puerto Rico to discover a suitable place for drilling. The project will be known as " Mohole " which is derived from the Mohorovicic discontinuity, called after the Yugoslav who discovered this feature of the earth's crust. At the Mohorovicic discontinuity, there is a layer considered to be the lower boundary of the earth's crust, beyond which there is a change in the nature of the earth's substance—to judge from a study of earthquake shocks.

The expedition, which will consist of four ships, is to study the possibility of using floating rigs to drill cylindrical bores into the ocean bed, and bring up cores of sediment. The area north of Puerto Rico has been chosen because the Mohorovicic discontinuity is nearer the surface of the water than elsewhere.

The technical director of the expedition, Dr. Bascom of the National Academy of Sciences, has said that the cores brought up should help to give a climatic history of the earth.

Letters to the Editor

STANDARD SYMBOLS

SIR, Ordinary freedom-loving citizens usually find those people who have sold themselves to some complete system of notational standards very trying to live with; for the latter have the habit of assuming that only into their hands have been delivered the tablets of the law as from Mount Sinai. I am, therefore, no advocate of hide-bound conformity to some published system; but recent experiences in the reading of printed examination question papers for different universities, including the University of London, have raised in my mind the query as to whether it is now time for the Institutions of Civil and of Mechanical Engineers to do at least a little tidying up. The dimensions of pressure, for example, I have found in a set of papers all bearing the name of one university to be given at different places in the following variety: lb/in.^{2}, lb. per sq inch, lb f per sq in, lb f/in.^{2} and, quite frequently, p.s.i., and each form is variously associated with alternative treatments of the full stop or period. Perhaps some degree of drill is called for. But systems of notation are not only for use in the setting up of examination papers. They should be in current use by teachers in the course of their prelections.

I think choosers of notation frequently forget that symbols are to be written by the teacher on the blackboard and by the student in his notebook, and systems which involve precise differences in spacing between letters and distinctions between roman and italic type faces are unpractical, besides requiring undue skill and application by compositor and proof-reader.

A page set up by a craftsman printer unburdened by adherence to an elaborate artificial symbolism may be aesthetically satisfying and, because of that, the more easily followed. But a compact page of technical matter bearing the full burden of recent symbolism induces a nausea in the sensitive reader which is to be overcome before he can understand its content.

My plea is therefore for some mild tidying-up while holding comfortably at bay for the present the notational zealots.

Yours faithfully, JAMES SMALL.

James Watt Engineering Laboratories,
The University of Glasgow.
21 April, 1959.

ONE TRACK MIND

SIR, From your Weekly Survey " One Track Mind Prevails," on 27 March, it appears that a monorail for carrying passengers from Central London to London Airport is still favoured.

This decision might be correct if London Airport were considered in isolation, but surely the type of transport selected should be suitable for switching passengers to Gatwick and Blackbushe as and when required, and from this point of view a connection off the Southern Region electrified lines near Feltham appears more attractive. It is difficult to believe that it could cost anywhere near £8 million—the estimated cost of the monorail—even if 1½ miles at the Airport end were underground. Waterloo, Victoria or even the air terminal at Earl's Court (via West Brompton and Clapham Junction) could be used as the London Terminus and the journey time non-stop should be of the order of 20 minutes. Certain lines near Clapham Junction will have to be electrified.

It is probable that Blackbushe will become a third major airport to meet future requirements. If so, it can easily be joined to the Southern Region near Farnborough. Connecting trains can then be arranged between the three airports without going via London as follows:—(1) London Airport–Gatwick via Clapham Junction, Herne Hill and Streatham, (2) London Airport–Blackbushe via Ascot, (3) Gatwick–Blackbushe via Redhill (reversal), Guildford and Farnborough (new connection). This arrangement would give a much more satisfactory all-round service than the monorail.

Yours faithfully, F. O. J. OTWAY.

Bexleyheath.
16 April, 1959.

SIR STANLEY ANGWIN

Sir Stanley Angwin, K.C.M.G., K.B.E., D.S.O., M.C., D.Sc., who will long be remembered for his outstanding contributions to the development of telecommunications in Great Britain and in the international and intercontinental fields, died a this home in Welwyn Garden City on 21 April.

Arthur Stanley Angwin, who was born in Penzance, Cornwall, in 1883, began his engineering career as an articled apprentice at Yarrow and Company Limited, engineers and shipbuilders. To further his engineering knowledge he then studied at East London College (now Queen Mary College), where he received a B.Sc. degree. In 1906 he began along and highly successful career with the Engineering Department of the Post Office.

In addition to his duties with the department, he interested himself in the Territorial Army for whom he recruited the Lowland Divisional Signal Company, comprised almost entirely of Post Office staff. During the First World War, Sir Stanley served in Gallipoli, Egypt, Palestine and France and was awarded the D.S.O. and M.C. He maintained his interest in Territorial Army work throughout the interwar period and commanded the 44th Home Counties Divisional Signal Company until 1927. Later he became deputy chief signal officer to Eastern Command.

Following his return to the Post Office after the Great War he was appointed to the wireless section of the engineer-in-chief's office, where his knowledge and experience were applied to the design and construction of high power radio stations at Cairo, Leafield and Rugby. He was closely connected with the establishment, in 1927, of the first transatlantic telephone service and in the subsequent development of short wave radio-telephone services to all parts of the world.

Sir Stanley's appointment as engineer-in-chief of the Post Office came not long before the outbreak of the Second World War. During this difficult period he commanded the respect and affection of his staff, much depleted by call-up, and evoked from them a response to overcome difficulties, however strenuous the effort required.

Sir Stanley represented Great Britain at many international radio and telecommunication conferences. As British delegate he attended the Telecommunications Conference in Madrid in 1932; Lucerne in 1934; Bucharest in 1937; Cairo in 1938; Montreux in 1939; Bermuda in 1945; Moscow in 1946; and Atlantic City in 1947. In 1945 he accompanied Lord Reith on a tour of the Commonwealth to discuss and to secure agreement on changes in Commonwealth communications. He was particularly noted for his patience in negotiation, which frequently led to his appointment as chairman of committees, especially those dealing with controversial matters.

He joined the Institution of Electrical Engineers in 1910 and was elected a member in 1922. He became a vice-president in 1939 and was elected President in 1943. In 1953 he was awarded the Faraday Medal of the institution and in 1956 he received the Certificate of Honorary Membership in recognition of his outstanding work in the field of telecommunications and his distinguished services to the Institution.

He was Knighted in 1941, appointed K.B.E. in 1945 and K.C.M.G. in 1957. In 1947 he was made an Honorary Fellow of Queen Mary College, and in 1953 the Honorary Degree of Doctor of Science (Engineering) was conferred upon him by the University of London.

I. V. ROBINSON

For 37 years Mr. I. V. Robinson, whose death occurred at his home on 16 April, was connected with the British Electrical and Allied Manufacturers' Association, concentrating his work on the heavy plant side. Even earlier, however, he had attended Beama meetings as the representative of Richardsons, Westgarth and Company and before he was 40 he had made a name for himself by the papers he had presented to the Institution of Civil Engineers on condensing plant, cooling towers, and the torsional vibrations of shafts. For the last he received the James Prescott Joule Medal and the Miller premium.

Isaac Vincent Robinson was born in West Hartlepool in 1879. It is an interesting note that both his father and his grandfather were JP's of that town. Attending first a private school he gained a Whitworth Exhibition in 1900 and a Scholarship in 1902. He also gained a National Scholarship to the Royal College of Science, where he studied for 18 months. His apprenticeship was served with the Central Marine Engineering Works at West Hartlepool and was followed by a brief period as a sea-going engineer before he joined Richardsons, Westgarth. In 1919 he joined the staff of Beama and remained with them till his retirement in 1955.

As secretary of the turbineand turbo alternator section of Beama, Mr. Robinson was in close touch with developments. In 1921 he was instrumental in getting the turbine builders to support Professor Callendar in his work on the properties of steam, work which ultimately led to the International Steam Tables Conferences in 1929, '30 and '34. He was actively responsible for the publication of the *1939 Callendar Steam Tables* and the *1940 Heat Drop* Tables."

Mr. Robinson also represented Beama on many bodies in this country, and visited Australia in 1933 to give evidence before the Tariff Board. He was a Member of both the Institution of Civil Engineers and the Institution of Mechanical Engineers as well as a Member of the American Society of Mechanical Engineers. In 1948 he held the office of president of the Whitworth Society.

A. P. CHALKLEY

By the death of Mr. A. P. Chalkley, on 19 April, the British technical press has lost the services of an editor with nearly half-a-century's experience in the shipping and marine-engineering fields.

Alfred Philip Chalkley died in London, after a short illness, at the age of 73. He received his early education at Tiffins School and his technical education in the engineering faculty at Kings College, University of London, where he took his B.Sc. (Engineering) degree in 1905. For the next four years, from 1905 to 1909, he was engaged on the development and construction of steam turbine engines at the Heaton Works, Newcastle upon Tyne, of C. A. Parsons and Company, Limited. In 1908, he had the distinction of sailing on the maiden voyage of the first Mauretania, as guarantee engineer for the firm's turbo-generating plant, which was the largest plant of its kind that had been installed in any merchant ship up to that time.

Later, he spent much of his energy furthering the successful development of the internal-combustion engine and, in the early days of the diesel engine, he collaborated for some time with Dr. Rudolph Diesel, in the latter's work at Munich. These endeavours led, in 1912, to the publication of Chalkley's well-known *Diesel Engines for Land and Marine Work*, which became a standard work of reference, being translated into French, German and Russian.

It was in 1912, also, that he found his life's work, in that he then joined Temple Press Limited as editor of *The Motor Boat*. He continued as editor of that journal, later renamed *Motor Boat and Yachting*, until 1955. For some twelve years, from 1933 to 1945, he was editor of *The Oil Engine and Gas Turbine*, and, in addition, he was editor of *The Motor Ship*, supervising every issue of that periodical from its inception in 1920 until the present time.

His manifold and abundant interest in all forms of shipping and marine engineering never ceased, and his enthusiasm for motor-boating led to his becoming a trustee of the British International Trophy (known as the Harmsworth Trophy in the United States), the blue riband of international motor-boat racing.

K. R. HOPKIRK

Rotating machinery occupied a central place in the working life of Mr. K. R. Hopkirk, who died at Rugby on 24 April. Until he retired on 31 December, 1958, Mr. Hopkirk was director and chief mechanical engineer of the British Thomson-Houston Company.

Mr. Hopkirk was born at West Ham on 10 June, 1893. After graduating at Emmanuel, Cambridge, he joined the BTH test department at Rugby in August, 1915. Four years later he was placed in charge of the turbine test and at the end of 1920 joined the design staff of the turbogenerator engineering department, becoming chief in 1939. In July, 1945, he was appointed assistant chief mechanical engineer of the company, and in 1949 became chief mechanical engineer. Later in the same year he was elected to the board of directors.

During the whole of his service with BTH Mr. Hopkirk was closely connected with the turbine organisation and its problems, and carried out much pioneer work, especially on mechanical matters. His research included the study of vibration and methods of balancing (on which he wrote several articles); the joint discovery with Kemball of the General Electric Company of America of the phenomenon of shaft whip in high-speed machinery, the analysis of its causes and the development of methods to overcome it; and, in conjunction with steelmakers, the development of large high-grade forgings. During the war he designed transportable equipment for the vibration testing and balancing of steam-turbine rotors, and investigated the shock-effects of partial steam admission on turbine blade vibration.

On the electrical side he was closely identified with the development of turboalternators up to the largest sizes during the past 30 years, especially with the design of 33 kV windings and the associated problems of surge protection. He was responsible for the design of the largest 3,000 r.p.m. air-cooled alternators at present operating in this country and rated at 75 MVA, 0·67 p.f., 33 kV. A new type of BTH turboalternator rotor winding, which involved a large degree of mechanical development, was invented by Mr. Hopkirk.

At the

ENGINEERING, MARINE, WELDING AND NUCLEAR ENERGY EXHIBITION

Olympia, 16-30 April

With the closing of the exhibition yesterday, the preparation for the next one will have begun. Regular bookings will already be entered on the stand plan, and new requests be coming in. This exhibition has differed from earlier ones in the long series in being held in the spring instead of late summer; an assessment of the success will therefore be very interesting and the promoters and exhibitors will be enabled to judge if the change was a good one. Descriptions of some items of plant and equipment on display have already appeared in our issues of 17 and 24 April; others are mentioned on this and the next page.

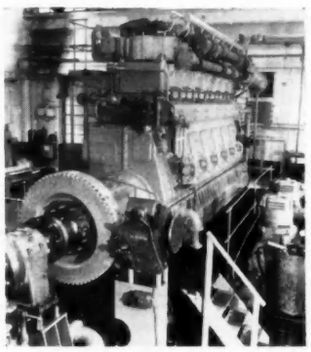
MARINE DIESELS

Range up to 4340 b.h.p. at 300 r.p.m.

A NEW range of Mirrlees engines, the "Monarch" class, for the marine field, covers powers from 1,600 b.h.p. at 200 r.p.m. to 4,340 b.h.p. at 300 r.p.m.

The range is made in three models of 6, 8, or 10 cylinders either normally aspirated or pressure charged. Bore and stroke are 19 in and 27 in respectively and the compression ratio is 11·35 : 1. The normally aspirated versions have a b.m.e.p. of 138 lb per sq. in, which is increased to 150 lb per sq. in for the turbocharged type. The engines are direct reversing.

The frame work of the six cylinder engine is made up of three castings: bedplate, column and cylinder casing. The bedplate carries the crankshaft in white metal lined steel backed bearings. The column forms the upper half of the crankcase and houses the camshaft, and the cylinder casing carries the liners. The cylinder head is cast iron and has two inlet and two exhaust valves, as well as the fuel nozzle cylinder relief valve and decompressor valve.



The pistons are oil cooled from the engine system by way of the main bearings, crankpin, connecting rod, and small end bearing. The return is through sight flow indicators.

Both the pistons and the connecting rods can be removed through the crankcase doors. The engines are suitable for multiple unit operation. *Mirrlees Bickerton and Day Limited, Hazel Grove, Stockport, Cheshire. Stand 5, Row P, Ground Floor, Grand Hall.*

DUST COLLECTOR

Unit Designed for Easy Replacement of Bags

THE Keith Blackman T1100 dust collector has been designed for ease of replacement and maintenance, offering also an increased filtration area and therefore better performance.

The removable filter-frame has been designed as a table-like structure which can be stood on the floor or bench. The filtering unit, arranged in block formation, consists of a number of close-weave bags, having a total filtering area of 50 sq. ft. The bags are contained in a frame which slides into receiving channels in the unit and is locked by two hand-nuts to form a leak-proof seal. The bags are held in a distended position by interior frames so that they always allow for free flow of air.

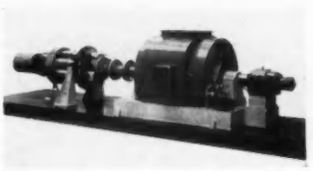
The open ends of the bags—at the top—are fixed and held in position by individual ring and nut assemblies and, at the closed (bottom) end, by steel rods, which form part of the shaking gear. When operated, the shaking gear causes the frame to be rapidly raised and lowered and the loosened dust falls into

a receptacle at the base of the unit.

Units required for immediate delivery are powered by 2 h.p. type BS a.c. motors, which, with the fan, are situated in the airstream, on the "clean air" side of the unit. *Keith Blackman Limited, Mill Mead Road, London, N17. Stand 1, Row A, Ground Floor, Grand Hall.*

3 MW GAS TURBINE ALTERNATOR

Mobile or Standby Set



THE Bristol Siddeley 3 MW turbo generator set is a lightweight plant intended to meet the requirements of public supply companies and others for peak load, emergency supplies, standby duty, or during the overhaul of other plant. Advantages claimed include low capital cost, automatic operation, high reliability and low maintenance coupled with a compact plant.

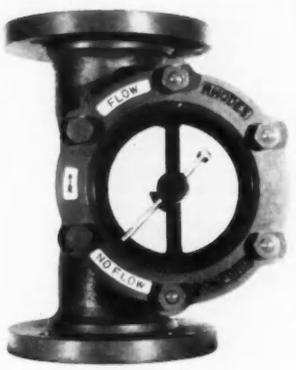
The power unit has been developed from the Proteus engine and like the marine version, will run on diesel oil. The engine is coupled to an air-cooled alternator of 3,200 kVA so that no water or other coolant is needed. Being a free shaft machine the unit requires only a small starting torque—enough to rotate the compressor. The output shaft is driven from the turbine wheel through a compound epicyclic reduction gear as in the aero version. All the accessories are grouped at the front of the engine.

Power for the starter motor is provided by a 110 V battery which also supplies those ancilliaries that have to be started before the main set. Once started, the sequence being automatic, a corrector motor, normally mains operated, opens the throttle until mains frequency is reached. Without the motor the set will run at 52 cycles on no load and at 50 cycles at full load.

For the same output the gas turbine set requires less floor space and is much lighter than a diesel set. It is also free from vibrations; both points enable lighter foundations to be used. Space heating of the building is not required as there are heating coils built into the alternator to keep the windings dry. Overhauls are only required about every 1,000 hours. *Bristol Siddeley Engines Limited, PO Box 3, Filton, Bristol. Stand 6, Row O, Ground Floor, National Hall.*

FLOW INDICATORS

General Industrial Use



RHODES sight flow indicators have been designed for general industrial use, the bodies being made strong enough to carry all strains, due to misalignment or movement of pipes without imposing any strain on the "Armourplate" glass windows.

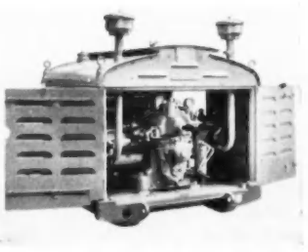
A range of eighteen different types is at present available, including the simple "look box" type, types with internal spinners, types with flaps and a type with a mercury switch operating a relay to make possible remote warning.

Since "Armourplate" glass can be more easily broken from a blow on its edge than on its face, the discs used in Rhodes indicators are completely encased in a metal clamping ring, excepting for the actual viewing area and at the same time are insulated as far as possible from damage by thermal shock.

The indicators are manufactured in a range of metals including stainless steel, pure nickel, monel, etc. They can also be supplied enamel lined and rubber lined. The normal design standard for the glass discs is 200 lb per sq. in working pressure but the majority of standard glasses fitted are suitable for working pressures well in excess of this. The present range of sizes is from ¼ in to 8 in bore. *B. Rhodes and Son Limited, Queen Street, Romford, Essex. Stand 25, Inner Row, Gallery, Grand Hall.*

POWER PACK

20 h.p. Air-cooled Diesel Set



THE Coventry Victor power pack is a portable unit producing 20 h.p., which is suitable for temperate and tropical conditions.

The unit comprises: the "Victor Vixen" four-stroke, horizontally opposed twin cylinder, air-cooled diesel engine, mounted on a steel bedplate and enclosed in a sheet metal casing incorporating hinged doors with louvres for ventilation.

The engine cooling is by means of a fan in the flywheel which circulates cool air around the cylinders and cylinder heads. The engine has been subjected to fully tropical tests in ambient temperature up to 138° F under MOT observation throughout its speed range without signs of over-heating.

Air cooling obviates the aggravating weight and bulk of radiator and fan equipment and makes for a lighter, more compact and less vulnerable plant.

Starting controls are located on top of the casing and the fuel tank is immediately above the engine for easy gravity feed. Air cleaners are mounted above the casing and out of the way of much of the ground dust, while the exhaust silencers are in protected positions under the bedplate.

An extension shaft to the flywheel enables the set to be direct coupled to driven machinery or may carry a flat, or grooved, pulley for side drive. Ring bolts are provided for easy lifting of the set. The total weight of the unit is 595 lb (271·45 kg) and this includes the 112 lb bedplate (50·9 kg). Overall dimensions are: length, 44 in; width, 39 in; height, 39 in. *The Coventry Victor Motor Company Limited, Coventry. Stand 6, Row J, Ground Floor, Grand Hall.*

PLATE BENDER

Vertical Machine with Capacity up to 4 inches

ONE of the largest available plate benders is a machine with a capacity for plate up to 4 in thick and 10 ft wide. The bending load is 3,000 tons. The machine has been designed to perform a variety of operations, and this versatility extends to the manufacture of drums and conical sections, and to normal pressing work.

In operation the main beam pins the plate against the feed roller which is contained in the fixed beam by four pistons, before the bending force of the hydraulic rams is applied. A particular feature claimed is that plates can be bent very close to the edge so that they can be chamfered on an edge planer to the correct profile before bending. When using plate 2¾ in thick, drums can be formed to a radius of 6 ft; for thicker plates the radius is greater.

The feed roller is driven from the main power supply by an underground shaft so that the floor is left clear. To remove the formed drum, the end of the top beam is hinged and can be lifted clear

by means of an eyebolt, using the ordinary shop crane. The bending bars on the moving beam can be taken out and the machine used as for normal pressing work which extends its usefulness.

The beam can also be set at an angle so that conical sections can be formed. For flanging the feed roller can be replaced by a nose bar. *Hugh Smith (Possil) Limited, Hamiltonhill Road, Glasgow, N2. Stand 17, Row A, Ground Floor, Grand Hall.*

HOLDING MAGNETS

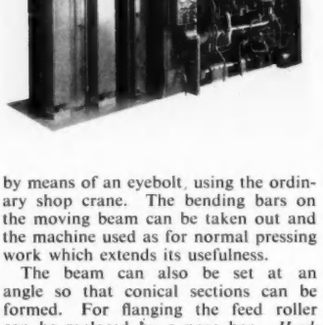
Positioning Unit for Welding and Fabrication

AN Eclipse magnetic unit has been developed for the purpose of holding workpieces in position during fabrication or erection.

The unit consists of two magnet blocks joined together by a swinging link. The two can be locked by tightening the nut on the link so that they will retain their relative position when in use.

Each block has one working face formed as a V and the other flat; both faces are energised at the same time, but each block has its own control. Apart from the contact faces which are finish ground, all surfaces are phosphated. The operating handles and end plates are diecast and the links joining the blocks are made of non-magnetic steel and are finished with a red crackle stove enamel.

The magnet blocks are similar to the firm's V block units and are made of mild steel and brass, incorporating Alcomac magnets. Pipes can be held in the V face, and flat material on the flat face, the arrangement allowing one block to be used for a pipe and the other



for a plate at the same time. The dimensions of each block are 2½ in by 2½ in by 2 in. *James Neill and Company (Sheffield) Limited, Napier Street, Sheffield 11. Stand 11, Inner Row, Gallery, National Hall.*

REFRIGERATED CONTAINERS

Self contained Units

MAINLY for marine use are the refrigerated containers made by J. and E. Hall. Each is complete with its own compressor and air cooler unit, built-in at one end.

The containers are made in various sizes but the standard model has a capacity of 500 cu. ft for stowage of cargo. This would allow some 6 to 7 tons of deep freeze material to be stored. Empty, the container when made in its light-weight form weighs about 3½ tons and so can be lifted by the majority of derricks installed on even the smaller size of cargo ships.

The main body is constructed of Homalloy and stands on steel beams to take the load. The lifting straps reach right to the bottom to distribute the weight when the container is being moved by a crane or derrick. They are usually placed on deck and are considered as deck cargo for most ships. Inside, the floor is covered with wood planks and there are shelves arranged on the walls, if desired, for storage of smaller items, or

the space can be left clear for larger packages as well as for meat.

The refrigerating unit is electrically driven and motors are available for most usual supplies. When the container has been placed in position all that is needed is to plug it into the nearest suitable mains supply available. The cooling circuit includes an air-cooled condenser with a Keith Blackman cooler fan and a circulating fan for the chamber. The arrangements can be adapted for any special conditions. Air is continually circulated through the machinery compartment. *J. and E. Hall Limited, Dartford Ironworks, Dartford, Kent. Stand, 7 Row F, Ground Floor, Grand Hall.*

RADIANT HEAT BOILER

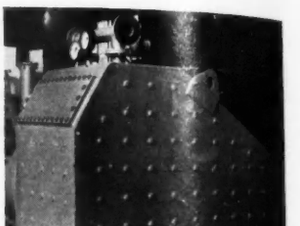
Coal or Oil Fired

THE Fraser hot water boiler is a radiant heat design with unidirectional water flow over the heating surface. Working pressures are up to 65 lb per sq. in.

The gas flow is arranged for two passes and the gas leaving temperature is quoted as 500° F. Operating efficiency is in the region of 75 to 80 per cent. The combustion chamber is designed to take automatic oil firing equipment or a mechanical stoker for solid fuels. Apart from coal or coke, fuels that can be used include wood refuse, begasse, nut shells, paddy husks, or other waste materials. It is also possible to adapt the chamber for gaseous fuels.

The furnace is completely water jacketed and the steep angle of the water tubes, besides promoting the unidirectional flow, also detracts from scale deposition. For steam raising a drum would be mounted at what is the normal water outlet connection.

The chief claims for the boiler are: its small floor space; the large volume



of water contained; rapid heat raising; easy access for inspection and cleaning; and the defined unidirectional water flow. There are ten sizes with outputs ranging from 1 million to 5½ million Btu per hour. *Fraser and Fraser Limited, Bromley-by-Bow, London, E3. Stand 8, Row K, Ground Floor, Grand Hall.*

FLAW DETECTOR

Ultrasonic Instrument for most Materials

THE Mark II ultrasonic general-purpose flaw detector incorporates fast time base speeds and high trace brightness combined with a rectified or unrectified trace display to enable a comprehensive study of flaw echo shape.

The operational frequency range of ½ Mc/s—10 Mc/s and a maximum depth range of 20 ft (in steel) extends the possible application range to include the testing of lead shielding blocks, graphite quality control, heavy section weld inspection and the checking of steel plate for lamination.

Vibrations are produced by a barium titanate or lead zirconate transducer designed to operate at an optimum frequency, mounted in a probe which varies according to the type of application. On single probe working the same transducer both transmits the vibration and receives the echo, converting it back into an electrical impulse.

The Mark II instrument uses a 5 in diameter cathode ray tube to show the condition of the material being tested, a

reflected wave giving a vertical deflection of the trace. The distance that this wave has travelled is indicated by the horizontal position of the deflection along the time base. The speed of travel of the time base is continuously variable by means of a coarse and fine control so that its total length may be made to correspond to anything from 1 in to 20 ft echo distance. A device is incorporated to enable the operator to select any portion of the display and expand it across the full time base length. *Ultrasonoscope Company (London) Limited, Sudborne Road, Brixton Hill, London, SW2. Stand 3, Row Z, Ground Floor, Empire Hall.*

HYDRO-PRECIPITATOR

Extracting Fine Dusts

A RANGE of wet film washers has been introduced by Keith Blackman for removing fine dust when large quantities have to be handled. Sizes run from 1,000 cu. ft per min upwards.

The dust laden air is drawn into the unit near the top. It is then drawn down at a velocity which ensures impingement on to the water, the first phase of the process of separating. The air is then drawn through a throat into the turbulent mixing area, designed to throw the dust into a continuous water stream.

The wet air and dust is then directed down once again on to the surface of the water into the area of maximum turbulence having once more passed through a continuous water curtain. The clean air is exhausted to atmosphere at the top of the unit after having passed through a series of eliminator plates. *Keith Blackman Limited, Mill Mead Road, London, N17. Stand 1, Row A, Ground Floor, Grand Hall.*

OUR BRIGHTEST SCIENTISTS

Space research projects were discussed in the House of Commons last week, and both Mr. Roy Mason (Labour) and Mr. Geoffrey de Freitas (Labour) pressed the Minister of Supply for a statement. Mr. Mason wanted to know what consideration was being given to proposals for using Blue Streak ballistic rockets to help in the launching of an earth space satellite, and to what extent the Ministry of Supply was working in cooperation with other countries of the Commonwealth in space research.

Mr. de Freitas asked how far space research investigations could be undertaken with the equipment which the Ministry was developing for the use of the Royal Air Force. He urged that when the Government were considering the next step in this matter they should bear in mind that there was a danger of this country losing her youngest and brightest scientists to the service of the United States unless they were given opportunities, from time to time, of carrying on scientific research. Such opportunities were necessary even if they involved using equipment which had originally been designed for a specific military purpose.

Adequate opportunities for Britain's scientists, Mr. Aubrey Jones agreed, were a most important consideration. He said that the United Kingdom missile programme could, with some adaptation, give an initial launcher in aid of a space research programme, but, of itself, could provide neither the satellites nor the instruments needed to attack the important scientific problems involved in space research. The Government were at present considering the question of a British space research project using earth satellites in the light of advice from the Advisory Council on Scientific Policy. A statement would be made as soon as possible.

The Government had in mind the scope which such a project would provide for cooperation with appropriate Commonwealth countries, but discussions could most profitably take place when a decision had been made on the scale and nature of any British effort. Asked by Mr. Frank Beswick (Labour/Cooperative) whether it would not be better to consult the Commonwealth countries before a decision had been reached about the scope of the British programme, Mr. Jones said he thought it proper to consult them only after any particular plan had been decided upon.

BETTER TRADE WITH RUSSIA

Useful preliminary discussions regarding Anglo-Russian trade have been held with the Soviet Ambassador in London. In this connection, Sir David Eccles, the President of the Board of Trade, told the House that, as a result of these talks, the British Government had proposed to the Government of the USSR that he should lead a small trade delegation to Moscow next month. The Soviet Government had welcomed that proposition. The delegation's purpose would be to negotiate an agreement to afford increased scope for trade between the two nations. Sir David said that the composition of the mission was under consideration, but he intended to invite two or three businessmen of standing to join the delegation as advisers, particularly on Russian exports to the United Kingdom.

Answering a point raised by Mr. Douglas Jay (Labour) about the kind of increase in trade that was hoped for, Sir David said it was impossible to say what the increase of trade might be, because that very largely depended upon the arrangments that Britain was able to make with the Russians to take up contracts which it was known that they already wished to place in this country.

The mission was not an endeavour to obtain orders. It was a mission set up to establish the right framework, within which businessmen could act afterwards. He told Mr. Emrys Hughes (Labour), who wanted Scotland to be strongly represented in the mission in view of the heavy rate of unemployment in that country, that representatives on the mission would not have any particular interests of that kind. They would merely be advisers on the general question of increasing the trade with Russia in both directions.

Sir David told Captain G. R. Chetwynd (Labour) that the strategic list would not be discussed, and Mr. A. Blenkinsop (Labour) that the Russians had made no request for long-term credit facilities He had, however, made some reference in the Budget debate with regard to medium-term credits.

FROM SHIPBUILDING TO CHINA

A number of members pressed the claims of particular industries to receive special consideration in connection with the mission. Captain E. W. Short (Labour) asked that a rather wide view should be taken of the word " trade " and that the needs of British shipbuilding should be borne in mind. He pointed out that a number of Russian orders for ships had just been placed in Western Germany, whereas similar orders given to Britain would be extremely useful in places like Tyneside. Sir David promised to keep this aspect in view.

It was suggested by Sir Anthony Hurd (Conservative) that it would be most useful to both countries if any buying Britain did in Russia were to be mainly of raw materials—such as barley, potash or phosphates—rather than of finished manufactured goods. In this regard, Sir David said that the Russians had a traditional trade in coarse grains and the mission intended to discuss that trade with the Russians. They also wished to have some opportunity to sell their finished goods to this country. He considered that Britain would have to look at that wish if she wanted to sell a great many more finished goods in the USSR.

Dr. B. Stross (Labour) drew attention to Russian purchases of consumer goods, including, for example, pottery from China, Czechoslovakia and Italy, and said that in the past the Russians had obtained the very best pottery from Stoke-on-Trent. Sir David agreed that the dessert services sent from Stoke-on-Trent to Russia were among the best in the world. He would certainly keep that fact in mind.

Told by Mr. E. Fernyhough (Labour) that Britain's cooperative movement had had a long-standing trade agreement with the Soviet Union, and that it would be helpful if people with experience over a long period formed part of the delegation, Sir David said he really needed advice about Russian exports to this country. There appeared to be plenty of orders which the Russians wished to place here, but as they were organised as a State trading body, he did not feel that the British mission was quite the means by which to try to make contracts. The Government were ready to consider anything to increase trade between the two countries.

LIQUID METHANE IMPORTS

Much interest continues to be shown regarding the recent importation of liquid methane from America. Mr. Alfred Robens (Labour) wanted the Paymaster General to explain the Government's policy respecting the substitution of imported liquid methane for coal in gas production.

In reply, Mr. Reginald Maudling said that there had been no change in situation since he had last answered questions on the matter. There had been one trial shipment of liquid methane. It was a novel experiment but further results must be obtained before it was determined what should be done with the process. The Government did not know how many tankers to build until it was understood whether or not the idea would work.

Certainly no instructions had been given to American shipyards for the reconstruction of tankers or for the building of new ones for the transportation of liquid methane, and he was glad to deny any rumours there might be. The Minister of Fuel was in consultation with the gas industry and the National Coal Board on the general question of fuel, used for making gas, but, he told Mr. A. M. F. Palmer (Labour/Cooperative), no one could begin to assess the economic advantages or disadvantages of the liquid-methane process to the country as a whole until more technical knowledge was available.

It was known that a full cargo of liquid methane carried by the Methane Pioneer was equal to about 5,000 tons of coal and that the ship could make 7½ round trips a year. Three or four more trial voyages would be required before the economic advantages could be assessed, one way or the other.

Asked by Mr. Harold Neal (Labour) whether it was intended to base the gas industry entirely on imported products, Mr. Maudling said that was not so. The policy of the gas industry was to base its production of gas on those products which would enable it to supply the cheapest possible gas to the consumer. On Mr. Robens pointing out that on the Labour side of the House they regarded the substitution of an imported fuel for an indigenous fuel as being, by and large, not a very good thing to do, Mr. Maudling said that the Gas Council had been doing extremely good work on this matter, but he was sure that they would take very careful note of what had been said.

He told Mr. Tom Williams (Labour) that, in considering what policy they should follow, the Government would certainly take into account the cost of redundancy when coal mines were closed.

Commonwealth Conferences at all Levels

Information about Commonwealth conferences to be held in the near future was provided in an answer given by Mr. C. J. M. Alport, the Under-Secretary of State for Commonwealth Relations. He told Mr. A. Fenner Brockway (Labour) that the Commonwealth Inter-Service Conference would take place in September and that the meeting of the Commonwealth Advisory Aeronautical Research Council would also be held in that month. As to earlier conferences, the Commonwealth Meteorological Conference would be held in May and there would be a meeting of Commonwealth senior economic officials also in May. The Commonwealth Education Conference would take place in July and a conference of Commonwealth survey officers in August.

Commercial Education Dragging

As soon as the necessary consultations had been completed, said Mr. Geoffrey Lloyd, the Minister of Education, he would announce his conclusions regarding the McMeeking report on commercial education. In the meanwhile, he said, he had told local education authorities that, after 1961, he proposed to give special priority to building projects for commercial education. Answering a point made by Mr. Michael Stewart (Labour), he said he would see that the National Coal Board and other nationalised boards were made fully aware of the desirability of granting day release to their employees for commercial education. He was taking steps to make it known to employers of all kinds that they should take this matter very seriously. Broadly speaking, technical education was swinging along well but commercial education was still hanging fire.

British Exhibitions in Moscow

Vice-President Nixon's visit to Moscow in July to open a six-weeks United States exhibition was brought to the notice of the Joint Under-Secretary of State for Foreign Affairs by Mr. A. W. J. Lewis (Labour). In reply, Mr. R. A. Allan said that the London Chamber of Commerce, with the support of the British Government, had recently been negotiating with the Russian authorities for an exchange of exhibitions between the United Kingdom and the Soviet Union in 1961.

Associated Electrical Industries

The trend of events in the industrial world is leading towards larger and larger groups in the electrical engineering industry. One factor is the Restrictive Trade Practices Act which, by increasing competition through the curtailment of collective price maintenance, is tending to produce amalgamations between firms. Another is the tremendous cost of research needed to carry out the necessary development in nuclear electricity generation. A third is the necessity to invest heavily in new plant in order to remain competitive in world markets.

These points were made by Lord Chandos, chairman of Associated Electrical Industries, in his annual statement to shareholders. He disclosed that his group would incur " substantial losses " on their contract in connection with the Berkeley nuclear power station. It was impossible at the time the contracts were entered into, he said, to assess all the difficulties or modifications entailed by this " entirely new adventure into the unknown." But, in common with the other three contracting groups, they had gained invaluable knowledge and experience, probably unique and likely to prove of great value in the future. Even this, however, was hard to assess.

One of the consequences of having to bear so heavy a risk on the outcome of such basic research and development was the need for very large resources. Expenditure on research and on modern plant was so heavy and had to be incurred so continuously that it was essential for the unit concerned to enjoy reasonable trading stability. This condition called for activities which embraced all aspects of electrical engineering since it was common for some parts of it to be booming while others were slack. The disappearance of collective price agreements, which were a factor in stability in bad times, would be followed by the dominance of a few large firms, each with their recognised share of the market—a situation which was most unlikely to have been envisaged by the supporters of the Restrictive Trade Practices Act.

The AEI group fared reasonably well in a period of depression. Order intake during the year was approximately 5 per cent less than in 1957, at £167 million. Over 10 per cent of the business, however, was in consumer goods such as domestic appliances and electric lamps, which hardly figured in the order book. Orders on hand were £182 million, and despite increased output (deliveries rose by £31·5 million) they were unable to reduce the figure by any significant amount. Trading during the first quarter of the current year showed " some, but not very marked improvement " over 1958 but Lord Chandos expected a further improvement in the latter part of the year.

Weapons More Intricate But Fewer

Adaptation to rapid engineering change is the aircraft industry's main preoccupation, and the growing complexity of airborne weapons its greatest problem. This was the theme of Mr. Donald W. Douglas, president of Douglas Aircraft Company Incorporated, when he lectured to the Graduates' and Students' Section of the Royal Aeronautical Society recently. He first discussed the relationship of the American aircraft industry with the United States Government and its assignments and responsibilities. He analysed the impact of missiles and other weapons systems on the industry and reviewed innovations in manufacturing methods involved in the production of these systems.

The changes that have come about during the past decade are so great that even an industry thoroughly used to adjustment and readjustment to changing times has found it difficult to keep up. In general, he said, the weapons systems that would be used in a major conflict in the 1959-62 period are now in final development or production. He doubted that a " major weapons system whose basic concept and design are fully approved today could be developed, tested, produced, delivered to a combat organisation, and used by that organisation in combat at the end of 1962 even under the impetus of the very highest and most expensive priorities." With such emphasis on research and development and complexities the cost of weapons has climbed to unbelievable heights. The estimated unit cost of the 1,610 aircraft for which provision is made in the United States budget for 1960 works out at £1½ million per unit. " There are no signs," said Mr. Douglas, " that a change in this trend is in prospect. In fact, as we enter the space age with its greatly increased performance requirements, the probability is that costs will continue to rise and that fewer weapons will be produced." One of the projects supported by the United States Air Force concerns the feasibility of machining new hard materials at rates ranging from 30,000 to 50,000 surface feet a minute.

Tyne and Clyde

Work on hand will keep the shipyards and engine works of Swan, Hunter and Wigham Richardson employed " at a reasonable high level " for the next two years but the further outlook does not look very bright. In his annual report the company's chairman, Mr. E. J. Hunter, states that with freight rates depressed the demand for new ships has practically disappeared and any resurgence of demand on a significant scale cannot be expected until there are indications of an improvement in this direction; such an improvement seems unlikely while the large volume of tonnage now laid up is available for service. Mr. Hunter pinned his main hopes on the modernisation of the whole group, which is " well advanced " and should enable them " to obtain their fair share of the work available under present conditions." Capital expenditure during the year resulted in net additions to fixed assets of £2·8 million and there are commitments by way of further expenditure amounting to £2·2 million.

Output in the shipbuilding units on the Tyne and Clyde was lower by some 6,500 gross tons than during 1957, at 122,500 gross tons. The output of the engine works showed a slight decline and the tonnage of ships repaired fell from 4·48 million tons to 4·18 million tons. Trading profits were down by nearly £370,000 to £2·3 million. There is little doubt, however, that Swan, Hunter, along with other large firms in the industry, have gone a long way to catch up their foreign rivals in respect of methods of construction and shipyard equipment.

Another large shipbuilding firm, the Fairfield Shipbuilding and Engineering Company Limited, have produced a very fine brochure showing something of the resources and facilities of their yard and engineering department. Many of the different types of vessels built and engined by Fairfield are illustrated and an impressive list of achievements (as well as customers) is given. The company have been producing engines since 1834 and next year they will celebrate their centenary as shipbuilders. The production of such a brochure, which is quite a departure for this type of firm, is welcome evidence that British shipbuilding intends to publicise itself and not leave everything in the world of public relations to the unmatched quality of their ships.

Recession Repercussions

The full damaging effect of the United States slump on manufacturing industry is being disclosed by company chairmen in their annual reports. Although some recovery is anticipated, few expect 1959 to be a golden year. Du Pont's report is particularly revealing: it shows both the extent of the damage and the reaction of American business under the strain. Sales fell by 7 per cent to $1,830 million, earnings were slashed—" because sales were off and higher costs occurred in almost all aspects of company operations "—and employment dipped from 89,000 to 84,000 over the year. This was only the fourth year in the last 20 when employment dropped. Expenditure on research and development totalled $90 million, 12½ per cent more than in 1957. To correct the poor earnings, an intensive study of costs was undertaken in 1958 and is still in progress.

A similar story is told by other firms, though none so large as du Pont and none who can boast of being " almost as old as the United States of America " (157 years of age). The Dravo Corporation—engineers, contractors, builders, shipbuilders, steel makers, and fabricators, employing 4,300 people—saw their net income contract from $5 million in 1957 to $2·05 million last year. The heavy fall in earnings was, according to the chairman, Mr. William K. Fitch, " caused principally by failure to make estimated profit on much of the work completed and unusually heavy expenses for investigation and development of new products." Link-Belt Incorporated, of Chicago, one of the world's largest manufacturers of mechanical handling equipment, earned $6·6 million last year as against $10·1 million in 1957. Sales were down by $22 million, to $142 million. Cummins Engine Company Incorporated, of Columbus, sold 2 per cent and earned 16 per cent below the previous year's levels, despite higher unit sales of diesel engines.

All these companies expect sales in 1959 to be higher than last year's. Du Pont predict " as good a sales year as any in the company's history." The others also look forward to better operating conditions (with the exception of Dravo, who lag behind the other companies in feeling the full impact of the recession), but none expects earnings to recover as fully as sales.

Oil Engines in India

An investment of $850,000 has been made by the International Finance Corporation (IFC) in Kirloskar Oil Engines Limited (KOEL), a publicly-owned Indian corporation, for the expansion and diversification of their manufacturing activities. When the expansion is completed KOEL will be the largest manufacturer of diesel engines in India. It will result in the manufacture in India for the first time of 80 to 440 h.p. diesel engines for stationary generating sets, small shunting locomotives, and marine auxiliary and propulsion units; of a 3 h.p. diesel engine specially designed for pumping sets in demand by small farm owners in India; and of bimetal bearings for use in internal combustion engines. The production of KOEL's present range of 5 to 40 b.h.p. diesel engines will be increased. KOEL have concluded licensing agreements with Glacier Metal Company for the manufacture of bimetal bearings and with Maschinenfabrik Augsburg-Nurnberg AG (MAN) for the manufacture of engines from 80 to 440 b.h.p.

KOEL are one of five public companies built up by the Kirloskar family. The original firm, Kirloskar Brothers, began in 1888 as a bicycle repair shop. In 1906 Kirloskar started manufacture of the Kirloskar iron plough, in 1926 the manufacture of hand and power pumps, and in 1937 the manufacture of machine tools, electric motors and generators and diesel engines. One of the companies is now the largest privately owned machine-tool factory in India. KOEL began to manufacture diesel engines in 1949 and export their products to Asian, African and Central American countries. Total cost of the expansion is estimated at $4·3 million, of which IFC's investment will provide one-fifth. The balance will be provided by additional share capital and by company funds.

Tempting Morsel

Increasingly industries and individual companies are trying to arouse the interest of school leavers and those just behind them in an industrial career. One of the latest has been a one-week course during the Easter vacation for boys and girls from public and grammar schools throughout the country. The course was organised by the Metropolitan-Vickers Electrical Company.

During that week some 40 fifth and sixth formers, eleven of them girls, went through a programme of progressive training. Half of each day was spent under instruction in the apprentice training school and the other half in the manufacturing departments and design laboratories. Talks were given by senior staff in the research, design, sales and manufacturing departments who explained the work they do as professional engineers and the opportunities which arise in electrical and mechanical engineering. They also met the director of research and education, Sir Willis Jackson.

Companies today consider it well worth their while to create a climate of interest in the schools. To overcome past prejudices concerning the acceptable respectable occupations is to ensure a reasonable supply of good quality recruits in the future.

Traffic Discipline

A gift of about £20,000 a year has been made for seven years to enlarge and develop the Birmingham University Graduate School of Highway Engineering. The study of traffic flow as an integral part of road engineering has only begun in this country. In the United States and Germany it has been developing for a number of years. Now, thanks to the generosity of several public companies and motoring interests further systematic study can be made here.

A proposed graduate programme in urban planning and traffic engineering has been recently issued by Yale University in the United States. Although these two are based on different criteria, says the pamphlet, the objectives of both are the same. City planning is concerned with the control of land use, traffic engineering with the planning, design and operation of traffic movement. The traffic engineering portion of the curriculum is based on engineering disciplines. Only those with an engineering degree from an accredited college may take the course.

Using Words Effectively

Much good advice was given to writers on scientific subjects by the speakers at the luncheon held last week by the Radio Industry Council in honour of the winners of the RIC premium awards for technical writing. Some of the best advice came from one of the winners, Mr. E. Lloyd Thomas, speaking on behalf of the guests. Mr. Lloyd Thomas, B.Sc., A.C.G.I., M.I.E.E., A.F.R.Ae.S., is chief development engineer of R. B. Pullin and Company and specialises in analogue computers. He feels very strongly on the subject of muddled writing: "much of the confusion that exists in our lives," he said, "whether in business or in a wider field, is due to lack of effective communications. Writing is a permanent form of communication and a great deal of this confusion could be avoided if people took just a little more trouble over the way they express themselves." He gave a few examples of what to avoid and of the qualities to cultivate: "the ideal is the use of sufficient words to describe the situation without padding and without omitting anything of importance."

The RIC awards—there are six each year—began in 1952. The object of the scheme is to make it more widely known throughout the world that the British Radio Industry is in the forefront of development, by encouraging publication of articles reporting British technical progress and achievement in radio, television and electronics. Fifty-nine entries were submitted this year and of the winners of the 25 guinea prizes one earned his award for the excellence of the material his article contained, although to Air Marshal Sir Raymund G. Hart, director of the Radio Industry Council—it fell "far short of the standard expected in respect of presentation and good English." The RIC are attempting to stimulate the flow of articles from the industry to the technical press: sometimes contributions will reach them which lack polish but have what every editor wants: clear thinking and originality. If those two elements are present, the rest will follow and few editors will mind doing the necessary editing.

In Cases of Redundancy

A redundancy agreement has been reached between the unions and the British Transport Commission for men in railway workshops who have to be dismissed for lack of work. Compensation is based on length of service. Men with very long service will also receive lump sums. The basic qualification is that a man should have three years' service. Such a man receives two-thirds of his rate of pay (less unemployment assistance) for two weeks. At the other end of the scale a man with 40 years' service receives two-thirds his rate for 13 weeks. Lump sum payments begin after 25 years' service. If a man cannot get work during the currency of the two-thirds formula he gets it extended for a further similar period until he finds work.

This scheme is likely to be an important landmark in wage negotiations in the engineering industry. Since it is the first of its kind in engineering and applies in a branch of the industry tied to the railways, which as yet lose money, it is likely to be taken by the unions as a minimum standard. Private enterprise, which has to make a profit, will be expected to offer more. Until now, the engineering unions have been able to quote only the terms of the miners' redundancy scheme. Now they have one of their own and it will be surprising if redundancy schemes do not now become fashionable.

New Guild Ties

Members of the Engineers Guild may now wear a special tie. It carries the letters E and G separated by an integral sign and is made up in Terylene. The colours are maroon for the ground and golden yellow for the monogram reproduced here.

Membership of the Guild is open to corporate members, graduates and students of the I.C.E., I.Mech.E., I.E.E. and I.Chem.E., so the wearing of the tie is the sartorial symbol available to these present or future professional engineers—provided they have also joined the Guild. The April issue of the Guild's *Journal* gives details of how the annual subscription (£3 for a corporate member) can be more than offset by savings of as much as £20 in reductions, discounts, etc., on insurance premiums—personal, motor-car and householder's. A charge of only 11*s* 6*d* for the tie, together with these savings, makes the Guild an attractive proposition.

This week the Guild itself has made a new tie. From 1 June it is to take over the functions of the Professional Engineers Appointments Bureau. Mr. J. Muil, M.I.E.E., registrar and secretary of the Bureau, and Mr. H. Bailey, assistant secretary, have been invited to join the Guild secretariat as registrar and assistant registrar of a new appointments division which the Guild is creating.

Members of the four institutions may use the services of the appointments division whether or not they are members of the Guild. For the time being, the division will be remaining at the bureau's present address—39 Victoria Street, London, SW1. The Guild's offices are only half a mile away at 78 Buckingham Gate, London, SW1.

Winged Inspector

Mr. T. P. Frost, chief test pilot of Armstrong Siddeley Motors since 1955, has been appointed chief test pilot of Bristol Siddeley Engines, the new company formed on 1 April by combining the resources of Armstrong Siddeley Motors and Bristol Siddeley Engines. In his new post, Mr. Frost will be responsible for the flight testing and development of Bristol Siddeley engines, which include the Olympus, Orpheus, Proteus, Viper, Double Mamba, Sapphire, the P.181 and P.182, at the company's flight test centres at Filton Aerodrome near Bristol, and Bitteswell Aerodrome near Rugby.

Mr. Tom Frost, who is only 36 years old, has already 21 years of service with aircraft. At the age of 15 he joined the Royal Air Force as a Halton apprentice and after three years' training went to the Middle East as an engine fitter in 1941. In 1944 he took a pilot's course in Rhodesia and later joined 149 Squadron flying Lancaster bombers. He then went to Central Flying School and subsequently became an A.1 instructor. After a certain time spent on jet instructing he qualified for a course at the Empire Test Pilots School at Farnborough. Experimental test flying on Valiants, Vulcans, Javelins and Hunters followed at Boscombe Down. One of his exploits was to roll the giant Vulcan V-bomber over the Avro factory on completion of tests at Boscombe.

Cupid Replacement

Missiles will in future strengthen hearts, not destroy them. The days of Cupid's arrows have given way to ICBM's and rockets to the moon, and techniques used to analyse radio signals from missiles in flight have been adapted to help doctors to diagnose arteriosclerosis in its earliest stages. This disease—hardening of the arteries—leads to strokes, heart attacks and kidney failures.

Scientists of the Lockheed Aircraft Corporation's Missiles and Space Division have developed a method whereby electronic equipment normally associated with missile weapons can be used to fight ill health. Electronic computers are linked to plastic cuffs wrapped around the ankles and wrists of suspected arteriosclerosis victims. Heartbeat pulsations and blood vessel vibrations are recorded on tape. Lightning-fast computers then translate these sounds into mathematical terms—points and lines on graphs. The figures show experts whether there are any abnormalities in the patient's circulatory system. This may enable doctors to spot the disease early enough for prompt and effective treatment. The American Heart Research Foundation and the School of Medicine of the University of Southern California have worked together with the Lockheed engineers for the past two years. It is an interesting example of fruitful cooperation between medicine and engineering.

Wrong Dose

The Human Element note "Dose Control" (6 March, page 299) described the radiation monitoring service offered by the Electronic Machine Company Limited incorrectly. The company do not employ a team equipped with film holders to visit clients' premises, but issue film holders to clients under contract, the films being subsequently returned to the Electronic Machine Company for checking and recording.

Thermonuclear Assembly

FUSION reactions may be expected to yield a net electrical output given certain conditions. To determine what these conditions are and how they may be created and maintained has been the object of much research. The results of this work to date, from the physics of plasmas to the engineering of ingenious plasma-containing devices, have been assembled in a collection of papers presented before a meeting of the British Nuclear Energy Conference on 29 and 30 April at the Institution of Civil Engineers. The Convention on Thermonuclear Processes was organised by the Institution of Electrical Engineers, and included sessions devoted to the development of thermonuclear devices in Britain; construction features of Zeta (zero energy thermonuclear assembly); contributions from the United States and USSR; engineering problems associated with new systems; and the constricted plasma and its future. The following notes are the assembled conclusions of papers delivered. A subsequent report will consider engineering aspects of thermonuclear work, including the modifications incorporated in Zeta 1A and the design of a fast pinch device at AWRE.

Summary of Conclusions

As a background to the present summary, attention is drawn to articles written for ENGINEERING by two of the principal speakers at the convention. 'Dr. A. A. Ware of the AEI Research Laboratory, Aldermaston, writing on "Controlled Thermonuclear Reactions," has outlined the history of this research and the theoretical principles on which it is based (vol. 184, p. 610, 1957); and Dr. R. J. Bickerton of the Controlled Thermonuclear Research Division, Harwell, has summarised the papers presented at last year's Geneva Conference, classifying the various devices mentioned in a comprehensive table (vol. 186, p. 824, 1958). Dr. Ware has also examined in detail the Geneva papers on pinch-effect (vol. 186, p. 796, 1958). Other reports on thermonuclear work published in ENGINEERING include the full text of a lecture given by Academician I. V. Kurchatov at Harwell in 1956 (vol, 181, p. 522, 1956), and a paper "Neutron Emission in High Current Gas Discharges," by Mr. H. A. B. Bodin and Dr. J. A. Reynolds of AWRE, Aldermaston (vol. 184, p. 538, 1957). An extensive description of Zeta appeared in ENGINEERING on 31 January, 1958 (vol. 185, p. 134), including an account of "What the Zeta Experiments Mean," by Mr. R. S. Pease, who was also a main speaker at the Convention.

Thermonuclear Criteria

The introductory contributions to the convention may most readily be summarised by reference to a series of graphs. Fig. 1 shows the variation of cross-section (or reaction probability) for four of these reactions with deuteron energy. Note: the deuterium-deuterium reaction (DD) gives two sets of products; thus deuterium (D) plus a deuteron (*d*), or deuterium nucleus, forms either tritium (T) plus a proton (*p*) and 4 MeV of energy, or helium 3 plus a neutron (*n*) and 3·25 MeV of energy. The reactions represented on the graph are indicated by the following equations:

$$D + D \rightarrow He^3 + n + 3{\cdot}25\ MeV$$
$$D + D \rightarrow T + p + 4\ MeV$$
$$D + T \rightarrow He^4 + n + 17{\cdot}6\ MeV$$
$$D + He^3 \rightarrow He^4 + p + 18{\cdot}3\ MeV$$

Other useful reactions involving lithium isotopes and yielding helium isotopes are:

$$D + Li^6 \rightarrow 2\ He^4 + 22{\cdot}4\ MeV$$
$$Li^7 + p \rightarrow 2\ He^4 + 17{\cdot}3\ MeV$$

The conditions which a thermonuclear reactor is required to provide include suitable values of power density and particle density. The relation between the power released per unit volume and the deuteron particle density at a temperature corresponding to 100 keV for DD and DT reactions is shown in Fig. 2. The power density in a fission reactor is shown for comparison. A plasma at these temperatures comprises a mixture of nuclei, from which the electrons have been stripped, together with these free electrons. Apart from problems of containment (achieved by a variety of ingenious field configurations) and of stability, it is necessary for the total energy yield to exceed losses due to escaping particles and to radiation. The critical temperatures for the DD and DT reactions, at which the power retained by the charged particles exceeds the *bremsstrahlung* losses, is shown by the points of intersection in Fig. 3 (the particle density, n_i, is 10^{15} ions per cu. cm).

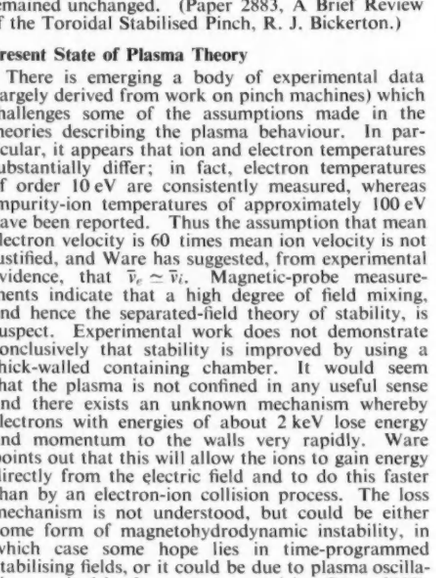
Considering a system heated to a temperature T for a time t and then allowed to cool and assuming a heat to electricity conversion efficiency of 33 per cent, it has been shown that the ratio, R, between the energy released in the plasma and the energy supplied must exceed 2. Thus, from Fig. 4 it will be seen that for a power-producing thermonuclear reactor using the DD reaction, T must exceed 2×10^8 °K (26 keV) and nt, the product of deuteron density with time, must be greater than 10^{16}. Hence for a pulse of 1 millisec duration, n must exceed 10^{19}. With the tritium-deuterium mixture, 3×10^7 °K is the minimum temperature and nt must exceed 10^{14}. (Paper 2888, The Basic Physics of Thermonuclear Processes, T. E. Allibone and D. R. Chick.)

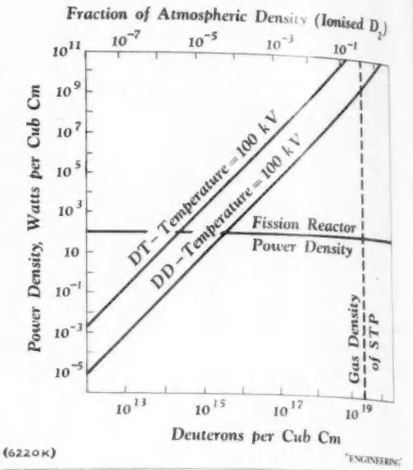
In the case of the toroidal pinch-machine Zeta, energy containment times of 100 microsec have been achieved and nt is about 10^{10}. In the Perhapsatron S4, where the gas current was sustained at a high value for a relatively long time by use of a subsidiary condenser bank, neutron emission continued steadily throughout the discharge lifetime, and despite a power input of 900 MW, the plasma temperature remained unchanged. (Paper 2883, A Brief Review of the Toroidal Stabilised Pinch, R. J. Bickerton.)

Present State of Plasma Theory

There is emerging a body of experimental data (largely derived from work on pinch machines) which challenges some of the assumptions made in the theories describing the plasma behaviour. In particular, it appears that ion and electron temperatures substantially differ; in fact, electron temperatures of order 10 eV are consistently measured, whereas impurity-ion temperatures of approximately 100 eV have been reported. Thus the assumption that mean electron velocity is 60 times mean ion velocity is not justified, and Ware has suggested, from experimental evidence, that $\bar{v}_e \simeq \bar{v}_i$. Magnetic-probe measurements indicate that a high degree of field mixing, and hence the separated-field theory of stability, is suspect. Experimental work does not demonstrate conclusively that stability is improved by using a thick-walled containing chamber. It would seem that the plasma is not confined in any useful sense and there exists an unknown mechanism whereby electrons with energies of about 2 keV lose energy and momentum to the walls very rapidly. Ware points out that this will allow the ions to gain energy directly from the electric field and to do this faster than by an electron-ion collision process. The loss mechanism is not understood, but could be either some form of magnetohydrodynamic instability, in which case some hope lies in time-programmed stabilising fields, or it could be due to plasma oscillations excited by fast runaway particles (Paper 2888). Attention was drawn to this extremely critical finding in the short survey of the Geneva Conference published in Atomic Review last 12 September.

Another paper suggests a third but somewhat less likely explanation of the loss: radiation from




Fraction of Atmospheric Density (Ionised D₂)
DT – Temperature = 100 kV
DD – Temperature = 100 kV
Fission Reactor Power Density
Gas Density of STP
Power Density, Watts per Cub Cm
Deuterons per Cub Cm
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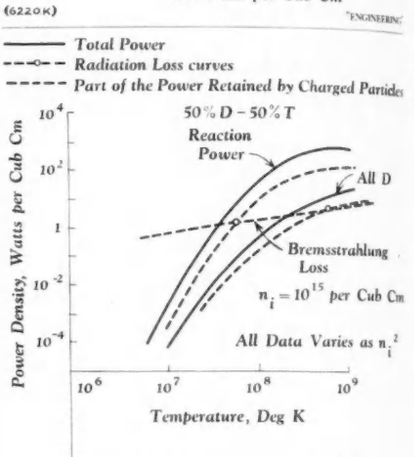
"ENGINEERING"



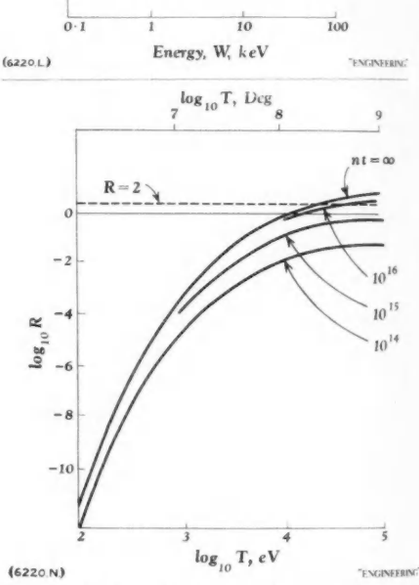


Fig. 1 (left) Nuclear fusion reaction cross sections as a function of relative particle energy (1 barn = 10^{-24} sq. cm).

Fig. 2 (top) Deuterium-deuterium and deuterium-tritium total reaction power density as a function of deuteron particle density (temperature = 100 keV or 10^9 °K).

Fig. 3 (centre) Calculated total fusion reaction power density (solid curves) from a thermonuclear plasma of density 10^{15} ions per cu. cm. The ignition temperatures are given by the intersection of the power-retained and radiation-loss curves.

Fig. 4 (bottom) Variation of R, the ratio between the energy released in the plasma and the energy supplied to it, in terms of temperature.

impurity atoms. The rate of energy loss to the tube walls is very high, although the discharges appear to be grossly confined away from the walls. Commenting on the two more likely explanations, the author observes:

"We know from the magnetic-probe measurements that in theory the discharge should be hydromagnetically unstable, and the neutron emission could be quoted as evidence that this is so. To improve this stability we need to know how to form a thin current sheet and so to obtain well-separated magnetic fields. Finally, the so-called electrostatic instabilities have been much discussed recently. It is proposed that space-charge waves or plasma oscillations are amplified by the interaction of electron streams with the plasma. The process is analogous to slipping stream amplification. It is further proposed that the fluctuating electric fields resulting from these oscillations enable electrons to cross lines of magnetic force and so to escape confinement. This last part of the theory is little more than a qualitative argument at present. The required initial streaming of electrons can be provided by the normal runaway process. If it is true that the process is initiated by runaway electrons, the instability can be stopped by operating pinches with higher line densities. Simple calculations using the theory of electron runaway show that substantial runaway is avoided if the number of ions exceeds 10^{18} lines per cm of discharge. The problem then is that very large gas currents (about 10^6 A) are required to obtain interesting plasma temperatures." (Paper 2883.)

Mechanism of Electron Energy Loss Suggested

The toroidaldis charge apparatus Sceptre III (AEI Research Laboratory) has been modified and is now known as Sceptre III A; the modification included new magnetic-field coils and improved measurement facilities. The experimental results obtained suggest that the electron-energy loss mechanism is due to an electron-particle bombardment of the walls. On this basis the large drift velocities observed for the ions have a simple explanation in the negative momentum carried to the walls by the electrons. The large ion velocities in turn lead to a simple and consistent explanation of the Doppler broadening on the basis that it is due to a true thermal motion. In addition, there is evidence that the electron loss is concentrated on those parts of the tube wall into which lines of magnetic force pass from the discharge space. A mechanism by which electrons can pass across the magnetic field and reach these particular lines of force is needed, and a simple argument shows that any region of higher density in the discharge will have a reversed component of electric field within it which will cause the electrons to drift outwards. The bars of light observed on all streak photographs may be such regions of higher density. If this is the case, the problem of the electron-energy loss reduces to the question: what is the cause of the bars? (Paper 2898, Sceptre IIIA, A. A. Ware.)

Two Basic Kinds of Fusion Device

The fusion devices proposed to date may be divided into two categories: (*a*) those in which the magnetic fields confining the plasma are largely produced by current in the plasma itself, as in the stabilised toroidal pinch; and (*b*) those in which the confining fields are produced by external currents flowing in metal conductors, such as mirror machines and the Stellarator. Type (*a*) machines appear to be essentially transient, or pulsed in operation, while those of type (*b*) may eventually be made quasicontinuous. During the period of operation, energy escapes from the plasma as photon radiation (*bremsstrahlung*), energetic neutrons, and other charged and neutral particles. All this energy may be converted indirectly to electrical power, but, in addition, some electrical power may be extracted directly. (Paper 2902, Possibilities of Direct Energy Conversion from Fusion Reactors, J. D. Jukes.)

Containment Systems Listed

Systems of containment so far reported are: linear and toroidal pinch (Zeta, Sceptre); Stellarator (with diverter); relativistic electron sheet (Astron); mirror machine, with adiabatic pumping and plasma injection (Scylla, Ogra, DCX); homopolar rotating plasma device (Ixion); ion magnetron; radio-frequency fields; and plasma loop (Osovetz). These systems have been compared in ENGINEERING by Bickerton (see references above). So far the bulk of British work has been devoted to linear and toroidal pinch systems, but the Atomic Energy Research Establishment has recently considered investigation of a machine with mirror geometry. A further system appearing to combine various approaches has been reported from the Atomic Weapons Research Establishment.

Fundamental Problems Outstanding

The main questions and problems which arise in connection with the toroidal pinch have been listed as follows: (*a*) In what form does the energy reach the wall in toroidal pinches? (*b*) What conditions are necessary to ensure a thin current sheet separating the axial and azimuthal magnetic fields, and how do these conditions scale? (*c*) What is the effect of reversing the external axial field on the stability of such a current sheet? (*d*) Experimental demonstration of the plasma heating produced by the interdiffusion of the initially orthogonal magnetic fields. (*e*) Experimental confirmation of the theory of runaway electrons. (*f*) Experimental measurements on the interaction between beams of charged particles and plasma. (*g*) More experimental evidence on the conditions under which the classical theory of diffusion of plasma across a magnetic field is valid. (*h*) Experimental verification of the shock-heating of plasma in the toroidal pinch by the rapid collapse of the plasma column. (*i*) Theoretical and experimental work on the stability of plasma and magnetic field under conditions of high acceleration. (*j*) What are the mechanisms of neutron and X-ray production lin toroidal pinches? (*k*) The identification of spectra lines from highly excited atoms. What information about the plasma can be obtained from impurity spectra? (*l*) The behaviour of toroidal pinches carrying currents of the order of 10^6A operating with line densities exceeding 10^{18} ions per cm. (*m*) The interaction between plasma and material walls. (*n*) The development of wall materials to withstand the arduous conditions involved, for example, high electric fields, heat fluxes, neutron bombardment.

It is clear that the solution of many of these problems has a direct bearing on other approaches to fusion involving plasma and magnetic confinement. (Paper 2883.)

Direct Conversion from Pinch Machines

Since electric currents and magnetic fields are essential to confine hot, fusing plasma, direct conversion from nuclear into electrical energy is suggested as being appropriate to fusion reactors. Qualitatively, the advantages of direct conversion are apparent. There is the possibility of achieving high thermodynamic efficiency, with a consequent saving in the bulk and capital cost of the intermediate heat-exchanging plant. If the nuclear energy is allowed to degrade to thermal energy, conversion would require the expensive accessories of some intermediate thermodynamic cycle.

A scheme has been proposed to convert directly some of the fusion energy liberated in a reactor working on the stabilised-pinch principle. In the usual concept of such a device, a toroidal cylinder of plasma is confined by an external azimuthal field. To stabilise this system, a longitudinal magnetic field of considerable strength is also required within the plasma. The plasma may be alternately compressed and expanded by modulating the pinch current about a mean value. A plasma containing a source of nuclear thermal energy, when taken through a compression-expansion cycle, does work on the confining magnetic field in a way analogous to the gas in an internal-combustion engine working against the piston. The efficiencies of two typical cycles, one in which the current has a sinusoidal modulation and one in which the modulation is a square wave, have been calculated. Although the former has practical advantages it turns out that only the latter can yield a significant conversion efficiency.

A fusible plasma confined by a magnetic field is made to undergo the thermodynamic cycle shown in Fig. 5. The plasma may be adiabatically compressed and expanded by alternately increasing and decreasing the confining field. At maximum compression, at temperature T_1, the plasma is hottest, fusion is most rapid and the plasma takes in heat energy. At maximum expansion, at temperature T_2, the loss of heat (presumed mainly by radiation cooling) exceeds fusion, and the plasma rejects heat. During the adiabatic expansion and compression "strokes," work is done reversibly between the plasma and the magnetic field.

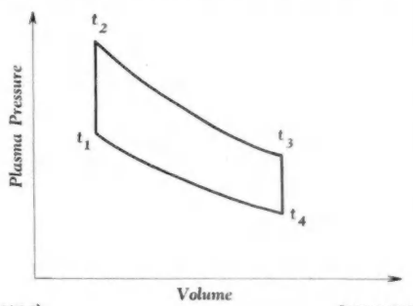


Fig. 5 A thermomonuclear plasma confined by a magnetic field might be made to undergo a thermodynamic cycle, thereby converting nuclear energy directly into electrical energy.

It appears possible to withdraw about one-third of the available energy from proposed fusion devices directly as electrical energy, thus saving about a third of the heat-exchanger-turbine capacity. A net power-producing reactor working on this principle would require a squarely modulated current of several million amperes for a deuterium-tritium mixture and 5 to 10 times as much for pure deuterium. For a 50 : 50 DT mixture the thermodynamic efficiency, η, is estimated to be 0·75 and the ratio, λ, of the expansion time to the compression time, of the order of 200; and for pure deuterium $\eta \simeq 0{\cdot}5$ and $\lambda \simeq 10$. (Paper 2902.)

Notes and News

Electric Field for Thermonuclear Containment?

The use of electric, as distinct from magnetic, fields for containing charged particles is reported to have been proposed by a group of research workers in California. An electric field is said to be easier to establish and control than a magnetic field, and particles once trapped are understood to be retained in orbit for several days. The special field required is created by the use of suitably shaped electrodes and by setting up both a.c. and d.c. voltages between them. Particles are trapped in stable orbits in a small volume contained by the electrodes. (*Journal of Applied Physics*, R. F. Wuerker, H. Shetton and R. V. Langmuir.)

Test for Electron Energy Loss?

The apparatus discussed in the preceding note permits particles of a given weight to be selected by varying the d.c. field, and of a given charge-to-weight ratio by altering the a.c. frequency. The shape of the orbit can be changed by adjusting the a.c.-to-d.c. voltage ratio. Particles ranging in size from electrons to dust can be isolated, and in charge-to-mass ratio, by a factor of 10^{14}. From a superficial reading of these results, it seems possible that the apparatus might be used to study the mechanism of electron energy loss noted in pinch machines.

Thermonuclear Course in France

The Commissariat a l'Energie Atomique, while pursuing studies begun three years ago, has this year organised a highly specialised series of lectures, aimed at the development of specialists in plasma physics: 40 sessions will be organised at Saclay, during the first half of 1959. The course, which began on 31 January, is being attended by about a hundred students, among them a number from abroad, to whom study grants have been made by Euratom.

Rolls-Royce and the Fuel Elements

Excitement in the House of Commons over the proposed manufacture by Rolls-Royce of nuclear fuel elements appears to have been caused by a failure to distinguish between processing and fabrication. Nuclear materials continue to be produced and controlled by the UKAEA, but there seems no reasonable objection to these materials being machined and canned by a private firm. Rolls-Royce are necessarily permitted to do so in that they alone, with the Admiralty's sanction, hold the licence to build and develop a nuclear submarine propulsion plant under the agreement with Westinghouse. This arrangement appears to be a consequence of the relationship between Government and industry in the United States.

G2 Supplies the French Grid

The French power and plutonium reactor G2 has supplied electricity to the grid. Its initial output was given as 9 MW but power is to be raised progressively to 25 MW representing a thermal output of 150 MW. G2 is at Marcoule.

ARCHITECTURE TO REFLECT A PROCESS

Flow line food production in a factory built for Heinz

"An engineer is essentially a specialist. In the construction of a factory you have involved the structural engineer, the process engineer, the ventilation engineer, the electrical, the mechanical engineers, and several others. You have a whole host of specialists and you must have someone there to coordinate them. I see this as the job of the architect."

It was, in fact, an architect speaking—Mr. Michael Ryan of J. Douglass Mathews and Partners. And as Mr. Ryan was the executive partner for the new factory of the H. J. Heinz Company Limited at Kitt Green, Wigan, costing of £6 million, he was able to argue from experience, and by example. A more detailed account of the civil engineering work at Kitt Green follows, but at present it is worth looking more closely at the part played by the architect.

To quote Mr. Ryan again, "The architect builds a building and at the same time he is also an artist. In fact he has three main tasks: to build beautifully, to build properly, and to build to serve a purpose. As it happens, we sometimes act as consultants to an engineer in charge of a building project, the idea being that he designs and executes the building and then turns to us and says now try and make it look beautiful. This is quite the wrong approach. I admire engineers, we couldn't possibly do without them, but an engineer is not an artist. You cannot design a building properly by constructing it first and making it look beautiful afterwards; for it cannot be great architecture, because there is no control over fundamental shape. And all building has a right to be beautiful. After all, it doesn't matter what it is, whether an engineer or an architect designs it, in 100 years it is going to be there and be called architecture."

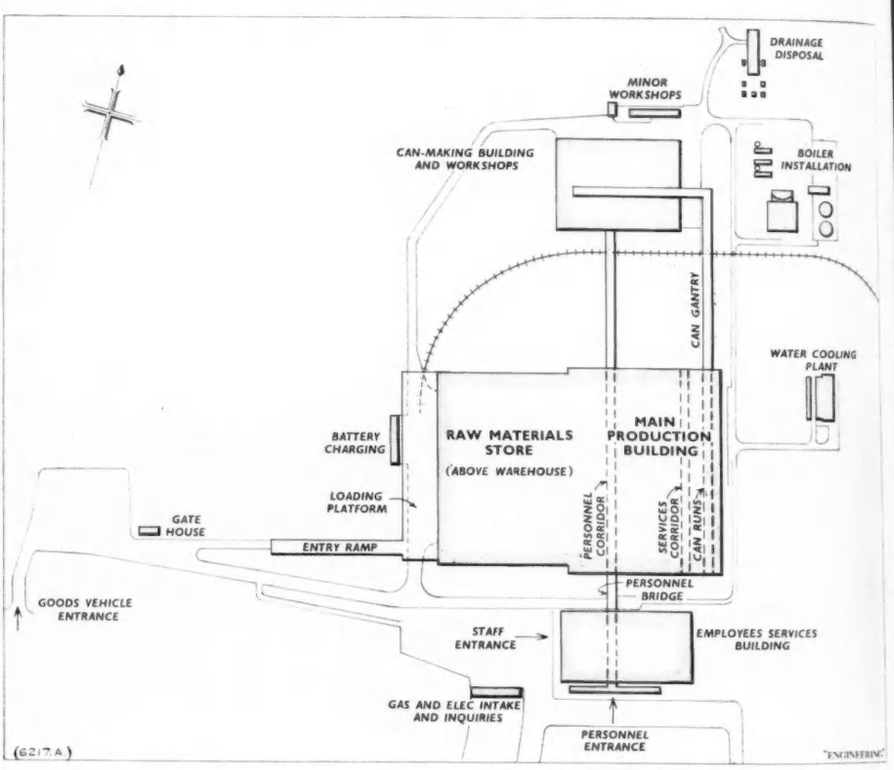
Fundamental Demands

The work of the industrial architect is well brought out by the Kitt Green project. There the problem was to provide a large factory building for the production of canned beans, soups, and similar products. The site had an appreciable slope; the process, although subject to much developmental change in detail, followed a well-defined pattern. Thus two main constraints existed to the number of possible solutions to the problem. The initial approach was the familiar engineering method: define the requirements quantitatively, examine the means available, produce tentative solutions, select one of them, carry out detailed design. Having examined the site, the architects discussed with the process engineers of Heinz the plant and services that had to be housed. It was found, for example, that it was not possible to pump most foods; for this reason a head of some 30 ft was required to allow liquids to flow under the force of gravity.

Other considerations were that the production area should be able to expand by up to 50 per cent and that it should be so constructed that changes in the machinery installed could be easily made as new food processes developed.

The size of the project, the restrictions of the site and expansion requirements, suggested a two-storey building might have advantages. Closer study showed that by the use of site gradient and ramped roads it was possible to introduce two working levels—a high level for unloading, storing, preparing, and cooking; and a low level for filling, sterilising, packing, warehousing and despatch. Two levels automatically gave the gravity head required and reduced the need for elevators. Other advantages of a two-storey building were the lower maintenance, the reduction in the roads and drainage required, and the shorter distances within the factory itself.

Pencil was first put to paper in June, 1954. The appointment of the consulting engineer—Mr. A. C. Aston, Manor Court Road, London, SW7—was also made about this time. The basic design was finally agreed on in March, 1955. During this period a great deal of discussion was carried on over the feasibility of a two-storey building, which at this date was—for the area and floor loadings involved—a departure from current practice. In the course of the discussions the opinion of the architects for the parent American company of Heinz—Skidmore, Ourings and Merrill—was sought, and they favoured the two-storey construction. This was finally accepted as the best solution.



Layout of the Heinz factory at Kitt Green, showing the disposition of the main buildings and production lines.

Detailed Requirements

Thus the problem of what to build was studied and discussed in an engineering manner from the start. An example of the sort of technical detail gone into at the time is provided by a questionnaire submitted by the architects to Heinz in October, 1954. This contains some 300 questions, which are in about 15 groups including the site, main services, transport, administration; and staff services. Concerning the warehouse, for instance, the following are some of the points raised: Total floor area? Maximum stacking height? Handling methods? Temperature, ventilation, and humidity? Loading docks? Method of working? Is covered loading essential? desirable? in whole or part? Single of multi-storey buildings? Precautions against vermin? Natural light requirements? Will all trucking be rubber tyred? Are the same trucks used throughout?

A typical detail that it is hoped to extract from such questions is the best structural module to suit the purpose for which the building is to be used. For example, in the present warehouse a wasted 2 ft above the stacked bales would represent a wasted volume of 280,000 cu. ft; forethought enabled such wastage to be avoided. In a similar way the most suitable structural module was found for the other parts of the factory.

This and similar coordinating work, occupies a large part of the time of the architect. It could equally well be done by an engineer, and is in fact done by them on many building projects. There is nothing "artistic" in the method. It is comparable with that of operations research. Both studies rely on the development of a systematic approach that can be applied to many complex individual industrial situations, and both coordinate specialists from different technologies to produce an efficient overall solution. It is conceivable that an operations research team could produce the detailed factory specification. This would give the architect more time to con-

sider the aesthetic aspects of his work, but would not give him such an intimate understanding of the process he is housing.

As so much of the industrial architect's work is the application of engineering and management principles, his only claim to do this work is his contention that the engineer takes little account of how his building will look. And it is unfortunately true that the engineer spends little time during his formal training considering what effect in general the products of his skill will have on people. The industrial architect is much more aware of expressing his own personality. In addition, he is conscious of the overall personality or character of the building, and realises that it should not be capricious but should bear some relationship to its function. Said Mr. Ryan: "Industrial building is the architecture of the present age. As for 'personality,' as you call it, we believe that the personality of industry is bound to show through well-designed buildings. We see this general character of industrial architecture as a certain 'preciseness.' That is why, for example, we were glad to be able to use red Accrington brick for the large windowless warehouse walls. We wanted to use it because it was the chief local building material, but we also jumped at the chance to use it because of the impression of preciseness it imparts."

Satisfying Solution

Was the Holoplast and curtain wall (some 72,000 sq. ft of it) put around the large production area specifically to let the personality of industry show through? This was not the main reason, answered Mr. Ryan, "The curtain wall has, of course, been much over used in this country, but not in this case. If ever, this was a case for having a vast area with no windows—after all, what do you use windows for: to give light and to see out of; and in a building covering 3½ acres you just cannot 'see out of' conventional windows. But, even with this vast floor area, if you take the glass right down to floor level you get a feeling of spaciousness and contact with the countryside wherever you are in the building. You can look out and see what the weather is doing, and you do not get the feeling of being shut in. And this makes it pleasanter for the people working there. All the way through this job we have had the aim that this building should be a pleasant place to work in."

At Kitt Green the architect has been successful. An impressive looking and efficient working factory has been produced without departing from sound engineering practice. The way in which services are distributed from a service corridor in a mezzanine floor between the upper and lower production floors is very effective, not only because it places the services efficiently but also because it meets the requirements of the food factory, namely, that ceilings and walls should be flush and carry no pipe or duct work that can harbour dirt. The mezzanine floor also leads to the efficient circulation of personnel—they do not have to pass through each others departments. The building should be a pleasant place to work in: the curtain wall and light colours give an impression of airiness and space through out the large production area.

The Building

The new factory of the H. J. Heinz Company Limited extends over about 42 acres of the 150 acre site at Kitt Green, near Wigan, Lancashire. The ground has a slope of about 1 in 40. Borings and soil tests carried out by Le Grand Adsco Limited, Southall, Middlesex, in 1955 showed that the subsoil was a firm boulder clay containing some stones to a depth of about 20 ft below the surface. The water content made the clay either near the plastic limit or below it. The shear strength and density of the clay was sufficient to permit normal foundations and the low compressibility indicated that no undesirable settlement was to be expected.

The general contractor was A. Monk and Company Limited, Warrington, Lancashire. Excavation started in November, 1955, and within two months the bulk of the excavation—about 200,000 cu. yards—had been completed. The foundations are reinforced concrete caps on bored piles, each pile cap carrying an average of 400 tons; individual piles carry about 45 tons. Piling was carried out by the Franki Pile Company, at times at rates exceeding 20 a day, the piles being anything from 30 to 35 ft long.

As can be seen from the plan, there are three main buildings: the main factory, the can-making building, and the employee services building. These cover 6½, 1½ and 1 acres respectively. The main factory is a two-storey building, with an overall height of 50 ft; one end is occupied by a warehouse (ground floor) and raw materials store (upper floor), and the other end by the main production section. The production floors each have an area of 150,000 sq. ft and the storehouse floors, 140,000 sq. ft. The difference between the height requirements of the storage areas and the production areas made possible the introduction of a mezzanine service floor between the two production floors. This floor contains all circulation corridors, lavatories and rest rooms; it also contains a packing store and quality control laboratories.

The main building is a steel structure. Steel was chosen for the production area because flexibility of internal plant arrangement wa required. For example, late in the construction of the building it was discovered that it was desirable to leave out part of the floor of the upper storey, in case tall equipment should be installed. It was a simple matter to make the alterations in the steel structure.

Reinforced concrete was originally chosen for storage building but a very competitive tender from Peirson and Company Limited, 20 High Holborn, London, WC1, to supply and erect a steel structure instead was accepted. In fact this company supplied all the structural steelwork —8,000 tons. The first section of the warehouse was handed over in April, 1957, and the remainder and the raw materials store by November of the same year. The change in plan has allowed Heinz the use of the large storage capacity for over a year already.

Because large spans are desirable in the production areas—to allow flexibility in the placing of equipment—it was first thought that the mezzanine floor could be contained within a 10 ft lattice girder. However, the large loads specified for the upper floor required a lattice girder of proportions that would make it difficult to insert items such as doors in it. And as the mezzanine floor serves a valuable function in allowing the easy circulation of staff, this was a disadvantage. Plated girders are therefore used, with supporting columns from the ground floor at 48 ft centres. The girders are 4 ft deep and the upper floor is supported on them by means of stub columns 8 ft tall and at 12 ft centres—no disadvantage on a service floor.

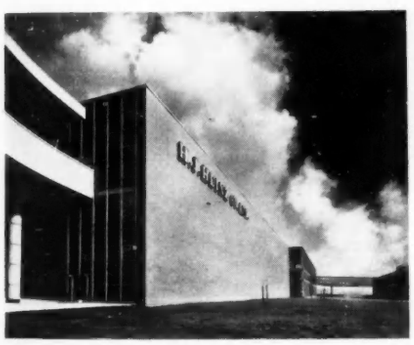
The actual column grid in the production areas is 48 ft by 16 ft and the permissible live load on both main floors is 350 lb per sq. ft. Analysis of the most likely spacing of services to the plant installed dictated the structural module: usual minimum spacing was found to be close to 12 ft, and a span of 16 ft was also a common measurement; the main span was therefore chosen as a multiple of 12 and 16. A feature of the steel work is the use of castellated beams. These give a lead through channel to the service floor at every 16 ft across the building. In the major part of the upper production floor, for example, where frequent washing down occurs, drains are laid through the holes in the beam webs.

In the warehouse section the structural module was decided by considering the sizes of the bales to be stored. The column grid adopted is 24 ft by 32 ft. The warehouse section extends to the combined height of the ground floor and the mezzanine floor and has a clear height of 24 ft; the permissible live load is 900 lb per sq. ft. The raw materials store on the upper floor has a clear height of 14 ft 6 in and a permissible live load of 475 lb per sq. ft.

Gradient Advantage

Most of the tins used for the canning of foods in the main building are produced in the adjacent can-making factory. At present the two buildings are space far enough apart to allow the main building to expand. The employee services building (ESB) is also capable of further extension. It is a reinforced concrete structure,

Curtain walling on the main production building, where baked beans are sorted and graded.



Flank of the raw materials store and warehouse.

Loading platform for receipt of materials going into store.

one of the reasons for this being that advantage has been taken of the natural slope of the site to insert water storage tanks under it: the tanks are of reinforced concrete and it was convenient to continue this form of construction throughout the building. Red Accrington brick is again used for the walls. The building contains offices, medical centre, cloakrooms and a canteen (capable of feeding three shifts of 700 people).

Site levels have allowed the main entrance of the factory to be placed so that personnel leaving buses can pass straight through the ESB to reach the mezzanine level by way of a bridge, without going up or down staircases. Within the mezzanine floor they circulate without passing through production departments, and on reaching the appropriate staircase go up to their own department directly.

To the north-east of the main building is the boiler plant—analysis of the meteorological records showed that the prevailing winds were south-westerly. Some of the other services buildings are also located at this position—compressed air, vacuum, water-cooling, and chlorination. The services to and from the area are carried to the main building by way of a trench, and this feature, together with the use of external boilers, is reminiscent of oil-refinery practice.

The main production floor behind the curtain walling.

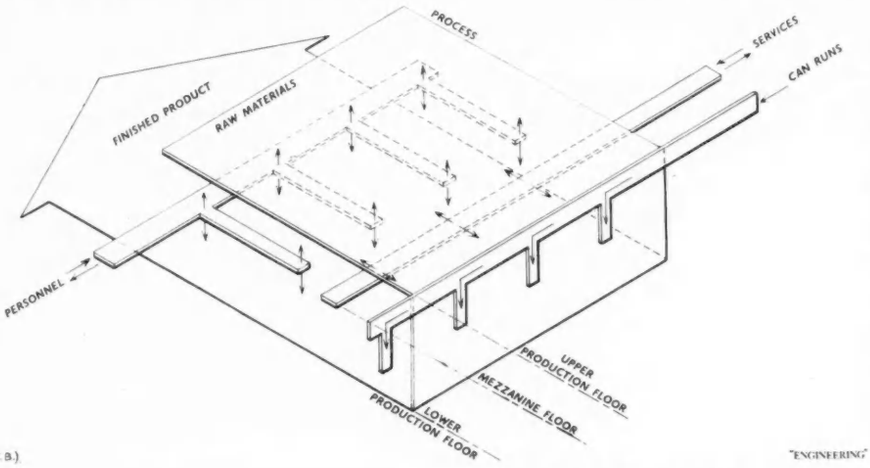


Diagram showing the horizontal and vertical circulation of personnel, materials and products.

The site gradient causes a drop in ground level of some 15 to 20 ft over the length of the main building. Ramps at the storage end of the main building enable lorries to drive up to the raw materials store or down to the warehouse. From the raw materials store, food is taken to the upper production floor to be washed, prepared, and cooked; it then flows to the lower production floor where it is canned, sterilised, and packed. The "kettles" in which food is cooked are located at the opposite end of the building to the receiving and despatch departments; access to the bottom of the kettles for servicing is obtained from the mezzanine floor. Empty cans from the can-making factory travel by gantry to enter the main building at mezzanine level close to the kettles; in addition, the main services come in at this end, passing right across the building in a service corridor. The way process, services, cans, and personnel, flow around the building is shown in the diagram.

The elevated loading bay for the raw materials store is a slab of reinforced concrete, 3 ft thick, supported by mushroom pillars. The ramp up to this is also of reinforced concrete and contains electrical heaters in its surface to prevent icing up. Kaylor and Pick, 42 Ferncroft Avenue, London, NW3, were the consulting structural engineers for these items. The spacing of the columns for the loading platform is dictated by the necessity of allowing freedom for vehicles to manoeuvre in this area below the platform. The design load is MOT loading for highway bridges, and the structure is carried on piles. The same goes for the ramp which is of beam and slab construction.

The canopy which extends over the loading area is constructed in reinforced concrete, and illumination is provided by a glass insert close to the main wall of the building. The canopy is 388 ft long and Corroglaze wire-reinforced sheets (type G) are used. They are fixed to steel-angle purlins and aluminium flashed. Prismatic ribbing on the underside of the sheets diffuses the light over the loading area.

No other use of roof lighting is made in the factory; three-ply felt roofing is used throughout. In the main factory a lightweight metal deck is used with fibre board insulation and steel purlins. In the employee services building woodwool slabs and pre-cast concrete purlins are used.

Hygienic Ceilings

The ceilings in the production building are an example of the adaptation of what has come to be regarded as the traditional type of ceiling—metal lath and plaster. Above food production processes Heinz require a hygienic ceiling that can be washed down and which will not have cracks that harbour dirt. Campbell Denis Limited, 48a Elizabeth Street, London, SW1, supplied and fixed the bracketing and lathing, which is a galvanised channel section. The sections are hung from the main structure by 1 in by $\frac{1}{8}$ in hangers, and from the sections are hung metal T's. The T's support $\frac{3}{8}$ in Asbestolux panels, which are coated, after fixing, with a permanent white cocoon of Tretoplast. The panels were supplied by Anderson Construction Company Limited, Euston Road, London, NW1.

The Tretoplast, which covers a total area of some 270,000 sq. ft, is a pvc-based film applied as a heavy spray. When the skin has formed it is continuous and can be cleaned down by hosing or detergent wash. It is produced by Tretol Limited, The Hyde, London, NW9. The lights for this ceiling are semi-recessed fluorescent fittings with moisture and insect proof plastics diffusers. There is 14 ft 6 in clear height in the upper production floor and 12 ft clear height in the lower production floor. The mezzanine floor has a clear height of 7 ft 9 in. The prefabricated openings through the floors, spaced at regular intervals, have been treated so that service pipes can pass through from floor to floor without affecting the structural waterproofness.

The upper floor of the production section is a 7 in reinforced concrete slab. The mezzanine floor, however, is made up from 7 in deep prestressed concrete beams—supplied by Pierhead Limited, Liverpool—strengthened by a 2½ in structural screed in conjunction with infiller blocks. This form of construction was chosen as it could be laid quickly and thus was soon available as a working platform for the propping of shuttering to the *in situ* concrete upper production floor; also, service holes could be provided through it by the removal of one or more infiller blocks without weakening the structure. A permissible live load of 140 lb per sq. in can be supported on this floor.

Within the production area the flooring has been carried out using Accrington brick paviors. As food acids are destructive to most cements, about five different samples of floor were laid at the Heinz factory at Harlesden, to see how they stood up to operating conditions. After a year it was clear that one was superior to the others. The construction of the pavior floors at Kitt Green was carried out by Acalor Limited, Crawley, Sussex. The procedure followed was to apply an impermeable membrane to the concrete slab, which had been screeded to include all necessary falls, and then bed the tiles in Acalor anti-corrosive cement No. 8. Pointing was carried out under pressure with Acalor No. 9A cement, which is a synthetic resin cement, resistant to a wide range of acids and alkalis, though not chloro compounds or aromatics. Pads have been inserted between finished floor levels and machine bases to enable all plant to be moved without affecting the floor finish. Demountable partitions have been used wherever possible.

Personnel Bridge

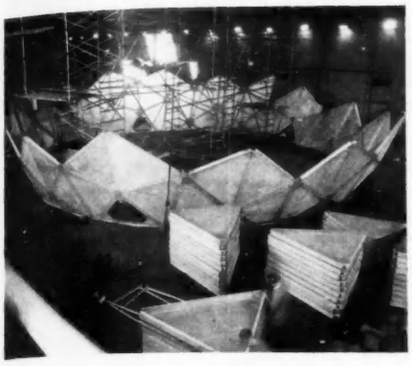
A succinct illustration of the architectural method is provided by the personnel bridge linking the employee services building with the main factory. When discussing the design of the bridge, Mr. Niels Lisborg, the consulting structural engineer for it, agreed that it was a good example of the co-operative nature of the project. Only the unexpected size of the array of pipes somewhat spoils its clean appearance.

Aesthetically, the appearance is intended to suit its purpose as a personnel bridge. The materials are meant to reflect and unify the concrete-framed employee services building on the one side and the curtain-walled factory on the other. The shape of the reinforced-concrete deck utilises the 3 ft 6 in rise from floor to floor, fits in simply at both ends, and avoids being unduly massive over the column. The proportions of the spans are to indicate that no support is taken at the curtain wall.

The reinforced concrete deck was cast *in situ* because the cross-section is so varied; it is reinforced by 24 Freyssinet cables from end to end. The roof is Q-deck only, spanning between structural Holoplast walls—similar to the walls of the factory. A single row of steel columns provides lateral support for the roof and supports pipe brackets.

SEVEN STOREY BUILDING IN 80 HOURS

Believed to be the world's largest glass fibre radome, 68 ft in diameter and more than seven storeys high, the structure shown in the photographs has been built by the Goodyear Aircraft Corporation, Akron, Ohio, USA. The radome



Start of the assemby process.

The finished structure, 68 ft in diameter.

has been ordered by the missile detection systems section of the General Electric Company's heavy military electronics department, Syracuse, NY, under a United States Air Force contract.

The structure is made up from hundreds of panels bolted together in basic five-panel groups. All the panels—except the four containing access portals, three round the base, one at the summit—are interchangeable, simplifying field service. A team of six men are able to erect or dismantle the radome in about 80 hours. Enough panels to construct it can be transported in eight American box cars or, at an all-up weight of 30,000 lb, can be carried to accessible points by military transport aircraft.

Resin reinforced by glass cloth, which is both fire and weather resistant, has been used for the panels. and the surrounds to the portals are made from glued timber laminations. It is claimed that, given proper anchorage, the dome will withstand 150 m.p.h. gales. Goodyear Aircraft have already made smaller radomes of 20 ft and 26½ ft diameter, and they are under contract to produce larger models of over 100 ft in diameter.

HELICOPTER HANGAR

A hangar for helicopters has been erected on a small island in the Persian Gulf by E. Chuter Limited for a British oil company. The structure, which has a clear internal span of 50 ft and an overall width of 79 ft, is built from prefabricated Heycon portal frames and covered with sheeting. So that work on the helicopters can be continuous, with shade temperatures at 130° F, the hangar is air-conditioned.

Loch Glashan Dam and Power Station

The North of Scotland Hydro-Electric Board have placed contracts for the main civil engineering works for their Loch Glashan scheme on Lochfyneside. William Tawse, Limited, Aberdeen, will build the dam at the loch, also the main aqueducts, the tunnel, pipeline, and generating station. Reed and Mallik, Limited will construct a system of collecting aqueducts and other works to make use of the upper River Add and the River Tunns. James Young (Contractors) Limited, of Glasgow, will build aqueducts and other works on the head waters of the River Crarae. The civil engineering consultants are Crouch and Hogg of Glasgow. The natural catchment of Loch Glashan is only 4 sq. miles, but another 20 sq. miles will be utilised by the collecting aqueducts. The power station will have a capacity of 6 MW.

Report on Mining Subsidence

A report *Mining Subsidence* has been completed after six years of work by a committee of the Institution of Civil Engineers. The committee were required to enquire into the " present state of knowledge of the effects of mining subsidence on the stability and durability of all types of civil engineering works and structures on or near the surface, including services and the drainage of the area," and to consider and recommend what research should be undertaken.

The work was divided among four subcommittees, dealing with structures, bridges, roads and public utilities. In each case, five main questions were considered—types of movements, effects of the movements, precautionary measures, remedies, and research. The report—5*s* (members), 10*s* (non-members)—is presented in similar groupings. A bibliography of 67 items drawn from home and oversea sources completes the report.

Power Station Orders

Two new reinforced concrete hyperbolic cooling towers, with natural draught, are to be built by the Mitchell Construction Company Limited, of Peterborough, at Padiham B Power Station, Lancashire. Each tower will be 300 ft high and will have a normal capacity of 3½ million gallons per hour. Work begins in the next few days.

Other civil engineering contracts recently let by the CEGB for work at power stations include:

Northfleet: coal handling plant, rail tracks and ancillary works—Taylor Woodrow Construction Limited.

Richborough: reinforced concrete piling—West's Piling and Construction Company Limited; coal-handling plant—George Wimpey and Company Limited.

West Thurrock: cranes—Stothert and Pitt Limited; ash-handling plant—Babcock and Wilcox Limited.

Padiham B: slag conveying plant—Mitchell Engineering Company Limited.

Uskmouth B: buildings and other works—John Morgan (Builders) Limited.

Insulated Pipework Underground

It has been customary to put pipework carrying fluids at temperatures appreciably above or below atmospheric temperature above ground on suitable supports. Stillite Products Limited, 15 Whitehall, London, SW1, have patented a new mineral wool pipe-insulating section which enables such pipes to be buried underground. The pipework is laid in a trench on temporary supports and covered by their Stilag insulating sections which are wired into position with lagging staples. U-shaped troughs are suspended from the insulated pipe by non-corroding rods and taped to form a continuous trough. The troughs are then filled with bitumen so as to fill all free space and to submerge the pipe and its fixings. When the bitumen is hard the trench is back filled. Details of the system, including recommended thicknesses of the insulation for use under given conditions, are given in the company's technical data sheets 16/59 and 7.

Progress on Dartford-Purfleet Tunnel

Miners working on the £11 million Dartford-Purfleet tunnel under the River Thames have broken through the last few feet of chalk separating the Essex and Kent halves of the main tunnel which has been driven outside the pilot tunnel built before the war. The tunnel, one mile long, lined with conventional cast iron segments, will allow a 21 ft carriageway under the river, making a four-mile link between the London-Rochester (A2) and the Barking-Southend (A13) roads.

On the average, 400 men have been engaged on the work for nearly two years. To assist tunnelling, pre-treatment of some of the more difficult strata was undertaken by grouting. The approach roads, three miles long, and the tunnel are expected to be ready for traffic during 1962. The consulting engineers for the scheme are Mott, Hay and Anderson, and Coode and Partners; Edmund Nuttall, Sons and Company (London) Limited, are the main contractors.

Contracts Let for Doncaster By-Pass

Contracts worth £6 million have been let for the motorway to by-pass Doncaster. The total length of new road will be 17 miles and there are 26 bridges along the route.

The northern section (12·8 miles) will be built by a consortium comprised of Holland and Hannen & Cubitts (GB) Limited, Fitzpatrick and Son (Contractors) Limited, and Lehane, Mackenzie and Shand Limited. The remainder (4·4 miles), which includes the Blythe by-pass, has been let to Sir Robert McAlpine and Sons Limited.

Graduate School of Highway Engineering

A number of interests, comprising the motor industry, oil companies, civil engineering contractors, motoring associations, Lloyd's and the British Insurance Association, has offered the University of Birmingham a gift under covenants of nearly £20,000 p.a. for seven years to enlarge the graduate school of highway engineering to include traffic engineering, and to establish a chair in the joint subjects.

The University will be considering the offer at the May meeting of the Senate and the Council. At the end of the seven years, the University will have to assume responsibility for the chair and the enlarged school. The donors have indicated that part of the gift is intended for bursaries for men attending the school.

Research and Design on Timber Roofs

A report, compiled by the Timber Development Association on behalf of the International Council for Building Research Studies and Documentation (CIB), has been issued reviewing trends in timber roof design in this country and oversea. The report, *A Review of Research Development and Design of Timber Roof Structures*, by E. Levin and P. O. Reece is available from the TDA, 21 College Hill, London, EC4, price 3*s* 6*d*.

The report covers both domestic and industrial roofs. Notes are given on stress grading, quality control, fire resistance and durability. Timber connector methods, gluing, nailing and reinforcement by high-tensile steel are also discussed. Various roof forms, including " advanced " shells, are briefly examined.

TRIUMPH HERALD

Easier Repairs and Improved Safety

By Gordon Wilkins

In designing the Triumph Herald, the Standard-Triumph group has broken away from current conventions to produce a small car with new safety features, which is easy to handle, easy to repair and requires the minimum of maintenance. In announcing it Mr. Alick Dick, managing director of Standard-Triumph said, " Not enough attention is paid to safety, to ease of handling and control and to the problems of parking. The cost of service has increased out of all proportion to the cost of manufacture in recent years. Manufacturers are able to apply massive capital expenditure to reduce labour costs, whereas by the nature of their work, garages have been unable to match this process."

His answer is a small car with easily replaceable body panels on a separate box section chassis which requires no regular lubrication. All-independent suspension is used for the first time on a small British family car and a 25 ft turning circle gives unusual manoeuvrability. The driving seat is adjustable for height, tilt and reach. The steering column is adjustable for length and incorporates a pin which is designed to shear in the event of an accident and collapse the steering column before the wheel buckles, thus protecting the driver from injury.

Says Mr. Dick, " We have laid the bogy that it is impossible to combine inexpensive body panels and cheap repairs with the Italian line." The Herald bodies are formed of seven panel assemblies bolted together and can be dismantled for easy repair. Detachable body panels are not unique; Citreon has them—but Triumph has gone further in reducing running and repair costs, eliminating all chassis points requiring regular greasing by using rubber, nylon or plastic bearings, or metal bearings with lubricant sealed in.

Practically the only existing components incorporated in the design are the 4 cylinder 948 cc o.h.v. engine and the gearbox which are inherited from Standard Ten and Pennant, models which have now gone out of production.

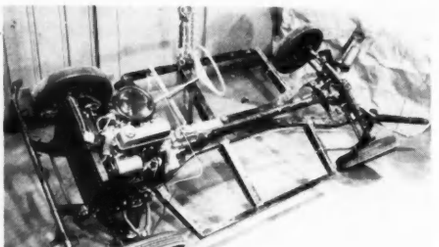
Body styling was done by the young Italian, Giovanni Michelotti. The basic model Herald is a two-door four-seater saloon of angular style with slim pillars, a large curved screen, big side windows and large rear windows. The same basic panels, with longer rear deck and a different roof are used with a twin carburettor engine to produce the sports coupe.

The box-section chassis frame has a backbone like an elongated X with box-section outriggers to support the body sides. Front wings and bonnet tip forward to give free access to engine, front suspension, steering and brakes, but the bumper and radiator grille are fixed. All panels are rustproofed steel. The roof panel, rear window framing and rear pillars are put together without soldered joints, slim chromium plated strips being used to hide the spot welds.

Front suspension is by semi-trailing wishbones with coil springs, telescopic dampers and an anti-roll bar. Steering is by rack and pinion and the unusual shape of the chassis frame permits exceptionally large steering angles. The top steering swivel is a ball joint and the lower one is a screwed trunnion bearing with its own oil reservoir. Rear suspension is a simple swing axle arrangement with a transverse leaf spring and a light forward-projecting torque arm at each side to transmit drive and braking forces. There are no sliding splines in the central drive shaft from gearbox to the hypoid final drive unit (which is insulated from the chassis by rubber mountings) or in the swinging axle shafts, and therefore no lubrication points. The exhaust pipe passes through a chassis cross member at the rear to ensure adequate ground clearance.

The rear wheel hubs have two bearings; a needle roller journal bearing without an inner race (the rollers run directly on the half shaft which is induction hardened locally) and a ball thrust bearing. The housing carries a shackle connecting it to the leaf spring and a pin for the longitudinal radius arm, which is connected to it by a rubber bush. Correct location of the rear wheels is obtained on the assembly line by adding shims as necessary between the chassis frame and the rubber bush by which the forward end of the radius arm is attached to it.

The Herald is a small family car designed for ease of handling and maintenance.



The chassis allows a very good steering lock; the body panels are bolted on.

Brakes have cast iron drums with two leading shoes at the front. Front drums are 8 in by 1¼ in; rear are 7 in by 1¼ in. Braking ratio between front and rear is 74 per cent to 26 per cent. Combined effects of all-independent suspension and low unsprung weight are said to produce unusually high braking efficiencies.

The engine is a four-cylinder in line o.h.v. unit of 948 cc, in unit with the clutch and a four-speed gearbox with synchromesh for second, third and top gears. Gear control is by a short remote control central lever.

As fitted in the saloon, with single down-draught carburettor and an 8 to 1 compression ratio, the engine delivers a net 34½ b.h.p (38·5 gross) at 4,500 r.p.m. with net torque of 48 lb. The car weighs 1,740 lb and has 5·20-13 tubeless tyres, giving 13·35 m.p.h. at 1,000 r.p.m. Performance figures quoted by the makers are: acceleration 0 to 50 m.p.h., 20 sec.; maximum speed 68 to 70 m.p.h.; fuel consumption 40 to 50 m.p.g.

The engine for the coupe has two carburettors and an 8·5 to 1 compression ratio, giving 42·5 b.h.p. installed at 5,500 r.p.m. (50·5 b.h.p. gross or SAE); max net torque installed is 48·8 lb-ft. The car weighs 1,695 lb dry, or 45 lb less than the saloon, and the axle ratio is 4·55 to 1, giving 14 m.p.h. at 1,000 r.p.m. Performance claimed is acceleration from 0 to 50 m.p.h. in 16 sec, with maximum speed of 76-80 m.p.h. Gearbox ratios on both cars are the same as those for Standard Ten and Pennant, with the exception of a higher second gear (2·46 against 2·6 to 1), which is equivalent to overdrive second in Standard Tens equipped with the Laycock overdrive and should make this a much more useful gear.

Engine construction is conventional, with three-bearing crankshaft, pump, fan and thermostat cooling. The fan has two blades, a four blade model being available for export. Inlet and exhaust manifolds are combined on saloon; separate on coupe.

Seats have foam rubber cushions and rubberised hair backrests supported on rubber webbing. Each front seat tips for easy access to rear seats and is spring loaded in the up position. The rear seat of the saloon moves forward and the backrest folds, giving an unobstructed luggage space through to the luggage trunk which itself has a capacity of 13 cu ft. Door to door width across front seats is 48½ in. Wheelbase is 91½ in and track, front and rear, is 48 in. Length, 153 in; width, 60 in; height, saloon, 52½ in; coupe, 51½ in. Kerb weight saloon 1,820 lb., coupe, 1,765 lb.

Interior trim is in diathermically welded plastics. Floor covering is carpet. On the saloon, the instrument panel is of light Prestfibre with a single plain dial in front of the driver grouping speedometer, fuel gauge and warning lights for dynamo charge, oil pressure, headlamp main beam and direction indicators; the coupe has separate fuel gauge and thermometer. Control knobs for choke, screen wipers, heater, key starter and master switch for lamps are grouped centrally with internationally recognisable pictorial markings. The change from side to head lamps and the change from dipped to main beam are controlled by a lever under the steering wheel. Another lever controls the direction indicators. There is a drop-down wire mesh parcel tray below the panel and both cars have coat hooks on the roof rail behind the doors. There is an ashtray in the centre of the facia, a glove box and a tray for cigarettes or sun glasses on top of the gearbox.

Standard equipment includes heater and demister or heater and fresh air blower. The rear registration plate lamp illuminates the trunk; the spare wheel is recessed in the floor. The fuel tank is inside the left rear wing and has a reserve tap. Designed for big production at a moderate price, the car has no excessive chromium decoration. Even the bumpers are painted and incorporated in the body panels, only the over riders being plated. The window frames are painted, but the coupé has a bright frame for the screen. The flexibility inherent in this method of construction will permit a convertible and station wagon to be added to the range eventually.

The Cornhill Insurance Company has already signified its faith in the repairability of the new design by offering Herald owners a reduction of 12½ per cent on the normal premiums.

VIRTUAL WORK *and* COMPLEMENTARY ENERGY *applied to Non-Linear Braced Frameworks*

By Professor J. A. L. MATHESON, University of Manchester

IN RECENT years, as a result of the work of Westergaard,[1] Charlton[2] and Brown,[3] it has become clear that methods of analysis of hyperstatic structures which employ the conception of complementary energy are valid for all types of structure, non-linear no less than linear, if the same load-deflection law is followed for decreasing as for increasing loads. On the other hand it has long been known that the most widely used theorems associated with the name of Castigliano must be restricted to linear elastic problems. These ideas are of great interest from the theoretical point of view because they enable some of the energy theorems of structural analysis to be logically and systematically related to one another.

These theorems form the basis of what Charlton[4] has called the "compatibility methods" of analysis in which the forces* in the redundant members are regarded as the unknowns. The procedure is to cut each redundant member and to apply pairs of quasi-external variable forces at the cut ends. The equations of equilibrium enable the member forces throughout the structure to be expressed as functions of the external loads and of the variable forces which are adjusted until the gaps are all closed and the conditions of compatibility satisfied; the magnitudes of the variable forces, which are then equal to the forces which must act in the redundant members of the complete structure, can be found from the corresponding simultaneous equations of deflection.

Any convenient technique can be used to find these equations of compatibility; if Castigliano's theorem, part II, is used, so that displacements are found by differentiating the strain-energy, the result is

$$\frac{\delta U}{\delta X_i} = \lambda_i \quad . \quad . \quad . \quad (1)$$

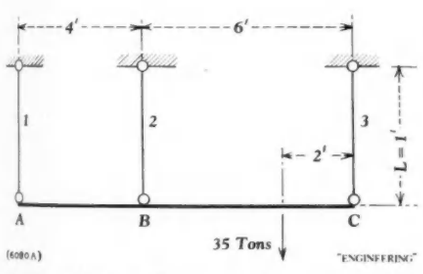


Fig. 1 The rigid beam A B C is supported by the three bars 1, 2 and 3 which are constructed of material obeying the stress-strain law of Fig. 2.

while if the members are a perfect fit before the frame is assembled equation 1 becomes

$$\frac{\delta U}{\delta X_i} = 0 \quad . \quad . \quad . \quad (2)$$

This result carries the implication that the strain-energy is a miniumum and for this reason Castigliano called it the "theorem of least work." Because of the risk of confusion with the quite different "theorem of minimum total potential energy," and in order to emphasise the logic of its derivation, the author[5] prefers to give the title "Castigliano's theorem of compatibility" to equation 1 and to regard equation 2 as a special case.

Corresponding to the above are two theorems which employ complementary rather than strain energy and so are valid for non-linear structures. Thus

$$\frac{\delta C}{\delta X_i} = \lambda_i \quad . \quad . \quad . \quad (3)$$

and, when the members fit perfectly

$$\frac{\delta C}{\delta X_i} = 0 \quad . \quad . \quad . \quad (4)$$

It seems logical to use the title "Engesser's theorem of compatibility" for the first of these in honour of the originator of the conception of complementary energy. Both Engesser's and Castigliano's theorems of compatibility require the solution of as many simultaneous equations as there are redundants and the procedure becomes very laborious when applied to highly redundant structures.

"Equilibrium methods," on the other hand, proceed in the reverse order. The conditions of geometrical compatibility are first used to obtain the relationships between the strains in the members and the deflections of those joints which are free to move. The conditions of equilibrium then enable the deflections of the joints to be determined as functions of the external loads. Finally the elongation of the members, and so the forces acting in them, are calculated. This order of procedure shows to best advantage when the number of degrees of freedom of the structure is small in comparison with the number of redundants; it is also noteworthy that the conception of redundancy is not employed.

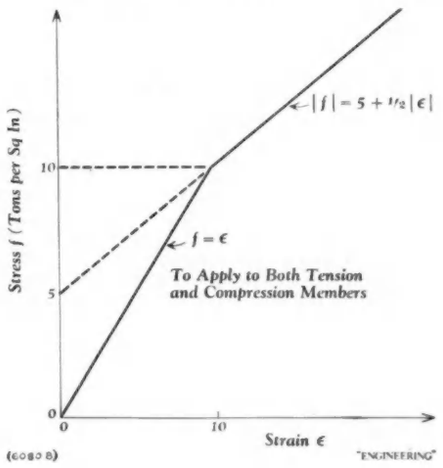
The equilibrium equations can be found by any convenient method. The principle of minimum total potential energy is often used, or a suitable version of the principle of virtual work, and it is of interest that since we are now concerned with equilibrium and not deflection the linearity or otherwise of the load-deflection relationship of the members is irrelevant. If the structure as a whole suffers gross distortion, however, so that the geometry of the frame changes appreciably, it will be necessary to avoid appealing to the principle of superposition.

In principle, therefore, there are two alternative systems for finding the forces in the members of non-linear hyperstatic structures but neither has been widely used to work out actual problems. There appear to be two reasons for this neglect. In the first place such problems do not arise very often in practice; even in the calculation of the collapse loads of structures, which has been intensively studied by Baker[6] and his associates, considerations of non-linearity have been avoided by the assumption of a rigid-plastic stress-strain law. In the second place even quite simple frameworks can involve formidable algebra, leading often to insoluble equations, if the members are assumed to follow a curved stress-strain law. One example of an attempt to solve a non-linear framework problem in numerical terms was given by King[7] who managed, however, to avoid the mathematical difficulties of an exact solution by using a technique of successive corrections.

It may well be that the increasing interest in the phenomenon of plasticity will stimulate the use of these methods in the future and for this reason the author has been studying them in some detail. It has been found that a new difficulty arises from the fact that it is essential to know in advance whether the members are in tension or in compression and, except in very simple cases, this is not possible. The procedure is therefore to make a guess at the signs of the member forces by visualising how the structure is likely to deform but if the guess is incorrect a solution will be obtained which apparently satisfies equilibrium and compatibility but is nevertheless incorrect. This rather elusive matter is now illustrated by analysing the very elementary structure of Fig. 1 first by the method of virtual work and then by Engesser's theorem of compatibility. It will be realised that even if the members obey a linear stress-strain law it is not possible to predict with certainty the sign of the force in member 1 since it depends on the relative extensibility of the three members.

The stress-strain law of Fig. 2 is assumed and, as a preliminary, the structure is first designed so that member 1 is in compression. The method used is due to Francis who has extended to non-linear frames a procedure originally suggested by Pippard.[8] If member 1 is chosen as the

Fig. 2 The stress-strain law for the material of the supporting bars of Fig. 1. It applies both to tension and to compression members.



* Similar arguments can be used to discuss rigidly-jointed frames in which there are redundant moments.

Symbols:

A	Cross-sectional area of member
c	Compression of member
C	Complementary energy
Δ	Deflection
ϵ	Strain
e	Extension of member
f	Stress
F	Force in member
F′	Force in member caused by unit load in redundant
F	Force in member caused by load P
λ_i	Initial lack of fit of ith redundant member
L	Length of member
P	External load
U	Strain energy
X_i	Force in ith redundant member

redundant a single equation of compatibility can be written with the aid of equation 4. Thus

$$0 = \frac{dC}{dX} = \frac{d}{dX}\Sigma\int e\,dF = \Sigma\, e\frac{dF}{dX} \quad (5)$$

where the summation is extended over all three members. Equation 5 can be rewritten in the form

$$0 = \Sigma\, \epsilon\, L\, F' \quad . \quad . \quad (6)$$

where F' is the force in any member when unit load is applied in the cut redundant, as in Fig. 3. The procedure is first to choose any system of forces F satisfying the conditions of equilibrium: a suitable set of forces is shown in Fig. 4. A pattern of strains ϵ is then selected by trial so that equation 6 is satisfied. Only values of ϵ greater than the "elastic limit strain" of 10 are tried and care is taken to use the same sign for ϵ as was chosen for F. The values of ϵ finally chosen are given in column 5 of the table, and column 6 lists the products $F'\epsilon L$.

Design of the Frame of Fig. 1

1	2	3	4	5	6	7	8
Member	L	F tons	F′ tons	ϵ	F′ϵ L	f tons per sq. in	A = F/f sq. in
1	1	− 3·5	+1	−15	−15	−12·5	0·28
2	1	+17·5	$-\frac{5}{3}$	+15	−25	+12·5	1·40
3	1	+21·0	$+\frac{2}{3}$	+60	+40	+35·0	0·60
					Σ = 0		

The stress f in the members corresponding to the chosen strain ϵ is evaluated from the stress-strain equation

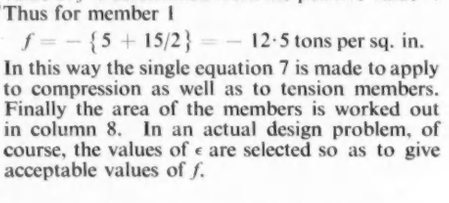
$$|f| = 5 + \tfrac{1}{2}|\epsilon| \quad . \quad . \quad (7)$$

and it is particularly to be noted that the sign of f is the same as that of ϵ but that the numerical value of f is determined from the positive value ϵ. Thus for member 1

$$f = -\{5 + 15/2\} = -12{\cdot}5 \text{ tons per sq. in.}$$

In this way the single equation 7 is made to apply to compression as well as to tension members. Finally the area of the members is worked out in column 8. In an actual design problem, of course, the values of ϵ are selected so as to give acceptable values of f.

Fig. 5 The structure has two degrees of freedom, conveniently taken as Δ_A and Δ_C.



We now proceed to analyse this frame using first the virtual work method and assuming that member 1 is in compression: the frame has two degrees of freedom, shown separately in Fig. 5, from which it is seen that:—

For displacement Δ_A:

$$e_1 = \Delta_A \quad e_2 = 0{\cdot}6\,\Delta_A \quad e_3 = 0 \quad \text{(i)}$$

For displacement Δ_C:

$$e_1 = 0 \quad e_2 = 0{\cdot}4\,\Delta_C \quad e_3 = \Delta_C \quad \text{(ii)}$$

Combining these gives the compatibility equations

$$e_1 = \Delta_A \quad e_2 = 0{\cdot}6\Delta_A + 0{\cdot}4\Delta_C \quad e_3 = \Delta_C \quad (8)$$

The equilibrium equations are conveniently obtained by means of Mohr's equation of virtual work,

$$\text{i.e. } \Sigma\, P\,\Delta = \Sigma\, F\, e \quad . \quad . \quad (9)$$

In this equation P and F are external loads and the corresponding member forces respectively while Δ and e are deflections and member extensions. In applying this equation it is

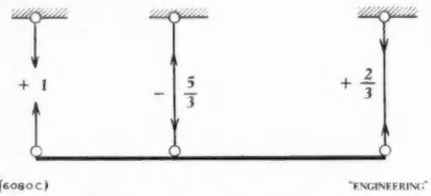


Fig. 3 Bar 1 is chosen as the redundant. Force F′ are induced in the members when unit loads are applied to the cut ends of member 1.

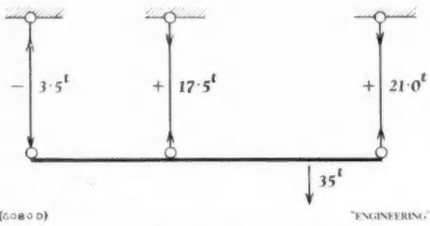


Fig. 4 A set of forces F is chosen which satisfies the requirements of equilibrium.

essential to use a strict sign convention: thus Δ is measured at the same point and in the same direction as P, while F and e apply to the same member and are positive if they represent tension and extension respectively.

Thus using expression (i) in (9)

$$35\,(0{\cdot}2\,\Delta_A) = (-F_1)\,e_1 + F_2\,e_2 + F_3\,e_3$$
$$7\,\Delta_A = (-F_1)\,\Delta_A + F_2\,(0{\cdot}6\,\Delta_A)$$
$$\text{i.e. } 7 = -F_1 + 0{\cdot}6\,F_2 \quad . \quad . \quad (10)$$

and using expression (ii)

$$35\,(0{\cdot}8\,\Delta_C) = F_2\,(0{\cdot}4\,\Delta_C) + F_3\,\Delta_C$$
$$\text{i.e. } 28 = 0{\cdot}4\,F_2 + F_3 \quad . \quad . \quad (11)$$

These are the equilibrium equations.

We have now to use the stress-strain equation (7) and the compatibility equations (8) to rewrite equations (10) and (11) in terms of Δ_A and Δ_C. Thus for member 2:

$$F_2 = A_2 f_2 = A_2\left(5 + \frac{e_2}{2}\right)$$
$$= A_2\{5 + \tfrac{1}{2}(0{\cdot}6\,\Delta_A + 0{\cdot}4\,\Delta_C)\}$$
$$= 1{\cdot}4\{5 + 0{\cdot}3\,\Delta_A + 0{\cdot}2\,\Delta_C\}$$
$$= 7 + 0{\cdot}42\,\Delta_A + 0{\cdot}28\,\Delta_C \quad . \quad . \quad \text{(iii)}$$

While for member 3:

$$F_3 = A_3 f_3 = 0{\cdot}6\left\{5 + \frac{\Delta_C}{2}\right\} = 3{\cdot}0 + 0{\cdot}3\,\Delta_C$$
$$. \quad . \quad . \quad \text{(iv)}$$

Member 1, being in compression, needs more care. Here we must write

$$F_1 = A_1 f_1 = A_1\left(5 + \frac{C_1}{2}\right) = A_1\left\{5 + \left(\frac{-e_1}{2}\right)\right\}$$
$$= 0{\cdot}28\left(5 - \frac{\Delta_A}{2}\right) = 1{\cdot}4 - 0{\cdot}14\,\Delta_A \quad \text{(v)}$$

Here c_1 is the compression of member 1 equal to its extension, $-e$. When the expressions (iii), (iv) and (v) are inserted in equations (10) and (11) it is found that:

$$0{\cdot}392\,\Delta_A + 0{\cdot}168\,\Delta_C = 4{\cdot}2 \quad . \quad (10')$$

and

$$0{\cdot}168\,\Delta_A + 0{\cdot}412\,\Delta_C = 22{\cdot}2 \quad . \quad (11')$$

The solution to these equations is:

$$\Delta_A = -15$$
$$\Delta_C = +60$$

from which F_1, F_2 and F_3 are obtained by substitution in expression (iii) to (v).

Thus $F_1 = 3{\cdot}5$ tons; $F_2 = 17{\cdot}5$ tons; and $F_3 = 21$ tons. These are the numerical values of the member forces; their signs are obtained by reference to equation (8). Thus $e_1 = \Delta_A = -15$, i.e., member 1 is in compression, as assumed. The other two forces are found to be tensile and the solution is seen to be completely correct.

It is now of interest to repeat the calculations on the assumption that the force in member 1 is tensile. If this is done it is found that equation (10) becomes

$$7 = +F_1 + 0{\cdot}6\,F_2 \quad . \quad . \quad (10a)$$

while expression (iii) is also changed:

$$F_1 = A_1 f_1 = A_1\left(5 + \frac{e_1}{2}\right) = 0{\cdot}28\left(5 + \frac{\Delta_A}{2}\right)$$
$$= 1{\cdot}4 + 0{\cdot}14\,\Delta_A \quad . \quad . \quad . \quad \text{(va)}$$

No other changes are necessary, but equation (10′) becomes

$$0{\cdot}392\,\Delta_A + 0{\cdot}168\,\Delta_C = 1{\cdot}4 \quad (10a')$$

Equation (11′) is unchanged and the solution to equations (10a′) and (11′) is

$$\Delta_A = -23{\cdot}65$$
$$\Delta_C = +63{\cdot}52$$

When these results are inserted in expressions (iii), (iv) and (va) it is found that:

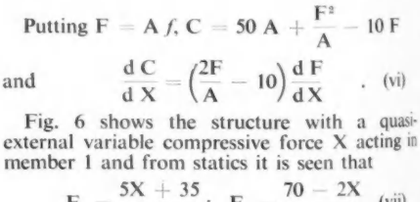
$$F_1 = 1{\cdot}4 + 0{\cdot}14\,\Delta_A = 1{\cdot}4 - 3{\cdot}312^* = -1{\cdot}912$$
$$F_2 = 14{\cdot}853 \text{ tons}$$
$$F^3 = 22{\cdot}059 \text{ tons.}$$

These results will be found to satisfy the conditions of equilibrium and they apparently satisfy compatibility, but we know them to be incorrect. The explanation is that, as the assumed sign of F_1 turned out to be wrong, we were in effect using the wrong equation for the stress-strain law for this member. This can be seen above at the point marked with an asterisk which is inconsistent in form with equation (7).

We now solve the same problem by means of Engesser's theorem of compatibility; readers who are familiar with the treatment of hyperstatic frames by means of "least work" will recognise the similarity of the two methods. First an expression is obtained for the complementary energy for one of the bars.

$$\text{Thus } C = \int e\,dF$$
$$= \int_0^{10} f\,A\,df + \int_{10}^{f} 2\,(f - 5)\,A\,df$$
$$= 50\,A + A\,f^2 - 10\,A\,f.$$

Fig. 6 In preparation for the use of Engesser's theorem of compatibility the frame has been cut back to a determinate condition by severing the redundant member 1. A pair of quasi-external variable external forces X are then applied at the cut ends of the member.



$$\text{Putting } F = A\,f,\ C = 50\,A + \frac{F^2}{A} - 10\,F$$

$$\text{and} \quad \frac{dC}{dX} = \left(\frac{2F}{A} - 10\right)\frac{dF}{dX} \quad . \quad \text{(vi)}$$

Fig. 6 shows the structure with a quasi-external variable compressive force X acting in member 1 and from statics it is seen that

$$F_2 = \frac{5X + 35}{3}; \quad F_3 = \frac{70 - 2X}{3} \quad \text{(vii)}$$

Hence

$$\frac{dF_2}{dX} = +\frac{5}{3}; \quad \frac{dF_3}{dX} = -\frac{2}{3}$$

Substituting expressions (vi) and (vii) in equation (4) gives:

$$0 = \frac{dC}{dX} = \left(\frac{2X}{A_1} - 10\right)1 + \left\{\frac{2}{A_2}\left(\frac{5X + 35}{3}\right) - 10\right\}\frac{5}{3}$$
$$- \left\{\frac{2}{A_3}\left(\frac{70 - 2X}{3}\right) - 10\right\}\frac{2}{3}$$

VALVES AND SEMICONDUCTORS

Outstanding Advances during the Past Year

During the past year or so, research and development in the field of electron devices has achieved some outstanding results. Not only have semiconductors advanced in giant strides through all stages of research, development, and production; but their predecessors and nearest rivals, the vacuum valves, have shown that they too are still capable of considerable further development.

These devices, together with cathode ray tubes, form the hard core of electronic engineering and it is often through their development that major advances in the engineering world arise. It is not surprising therefore that valves, semiconductors, and cathode ray tubes exhibited at the 1959 British Electronic Component Show from 6-9 April, created a good deal of interest.

One of the most significant advances in the field of semiconductors is that transistors are now invading the VHF bands. Several of the major firms in this field are now producing transistors of germanium and silicon capable of working at hitherto unheard of frequencies for transistors. For instance, Semiconductors Limited, Cheney Manor, Swindon, Wiltshire, are now manufacturing micro alloy diffused transistors for millimicrosecond switching, r.f. power oscillators, and r.f. amplifiers working up to 200 Mc/s. The same company also produce silicon alloy transistors which provide performance similar to that of surface barrier transistors in ambient temperatures as high as 120° C. Also using silicon, the Brush Crystal Company Limited, Shore Road, Hythe, Southampton, have produced power rectifiers working up to 700 volts peak, and 1 ampere forward current, at a maximum junction temperature of 150° C.

The characteristic spreads occurring between individual transistors, due to the manufacturers' difficulty in maintaining accurate consistency in production, has often been troublesome to large-scale users of these devices. However, at least one transistor manufacturer, Mullard Limited, Torrington Place, London, WC1, have taken steps to overcome this difficulty. They are now making available to bulk purchasers, packages of specially selected and tested transistors for use in the r.f. and a.f. sections of radio receivers, and in a.f. amplifiers. Each package is guaranteed to provide a minimum overall gain figure, when used in suitable circuits.

The Mullard a.f. package comprises a matched pair of OC78's suitable for push-pull class B output stages, and an OC78D driver transistor specially tested to precede the OC78's. In radio receivers the package will provide the audio amplification normally required, and will provide an output of 500 to 600 milliwatts, with a maximum input requirement of 30 microamps. Using the package, amplifier gains of 4 to 5 dB higher than the average figure obtained with randomly chosen transistors are achieved, and the spread in gain is reduced to a guaranteed maximum of 9·5 dB, thus simplifying the design of negative feedback amplifiers.

In the sphere of conventional thermionic valves, one of the most important advances during the past year has been the development of the frame grid. This type of grid, which is now being mass-produced, offers some outstanding advantages in performance and reliability which cannot be achieved with conventional grid techniques. The rigidity of the frame enables very thin (10 microns) grid wire to be used resulting in greater electron control and smaller spacings between electrodes. The increased electron control enables higher slopes to be achieved and the smaller spacings reduce the transit-time noise level.

The first large-scale use of this grid technique has been made in connection with a new television tuner amplifier, the PCC89. This valve is a twin triode, r.f., cascade operated amplifier, manufactured by Brimar Limited, Footscray, Kent, and Mullard Limited. Due to the properties of the frame grid, the PCC89 has a mutual conductance about twice that of any conventional grid valve of similar size, and it has low noise characteristics. The grid pitch has also been specially designed to achieve a vari-mu characteristic which will minimise cross-modulation interference when the valve is used in the front end of a television receiver.

In the microwave region, one of the most recent developments has been that of the KLS2, which is a 3-cavity klystron with a power output of 1,700 watts at 2,650 Mc/s, manufactured by the Marconi Osram Valve Company Limited, Brook Green, Hammersmith, London, W6. This company have also developed the GHT4, a hydrogen-filled pulse modulator rated at 25 kV with a maximum peak current of 2,000 amperes.

Ceramic valves, which reached an advanced stage of development in Germany during the last war, have been relatively slow to appear on the scene in this country. It is difficult to understand why ceramics, which are far more rugged and can work at much higher temperatures than glass, have not been used more by British valve manufacturers. However, at least one firm, Ferranti Limited, Ferry Road, Edinburgh 5, have been developing techniques for using ceramic in place of glass for some years, and they have now produced another in their range of ceramic valves. Known as the UL11, this valve utilises the properties of ceramic to operate as an oscillator/amplifier at 1,000 Mc/s, with a maximum peak power of 15 kW.

One of the main features of cathode ray tube development during the past year has been the widening of the deflection angle. Most of the major c.r.t. manufacturers are now making 110° deflection tubes, the main advantage of which is the reduction in the depth to screen size ratio (ENGRG., 23 Jan., '59, p. 128).

Concluding **Virtual Work**

$$= \frac{X}{0{\cdot}14} - 10 + \frac{50X + 350}{12{\cdot}6} - \frac{50}{3} - \frac{280 - 8X}{5{\cdot}4} + \frac{20}{3}$$

From which $X = 3{\cdot}5$ tons. Expressions (vii) now give $F_2 = 17{\cdot}5$ tons and $F_3 = 21{\cdot}0$ tons. It will be found that if these calculations are repeated with X tensile the solution is:

$X = -1{\cdot}91$ tons; $F_2 = 14{\cdot}85$ tons; and $F_3 = 22{\cdot}06$ tons.

These are the same incorrect values as were obtained before. Although the explanation of the error must also be the same it is not at all easy to identify the point in the calculation where the error occurs; it is in fact in the expression for the complementary energy which is only correct if the sign of F is correct.

We have thus demonstrated that in this type of problem the solution must always be suspected if the sign of the force in any of the members is opposite to that assumed. The calculations should be repeated with this sign reversed. It only remains to point out that this difficulty does not appear when linear frames are being analysed.

Acknowledgment.—The author records with gratitude the great help he has obtained from discussion of these matters with Professor A. J. Francis of the University of Melbourne.

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Mechanical Engineering Research Laboratory Changes to

NATIONAL ENGINEERING LABORATORY

The Council for Scientific and Industrial Research have announced that, from now on, the Mechanical Engineering Research Laboratory, East Kilbride, near Glasgow, will be known as the National Engineering Laboratory. This change, in name only, has been made in order to emphasise the national character of the laboratory, which is a part of DSIR and is financed by public funds. The work will continue to be concerned with the problems of mechanical engineering.

The object of the laboratory is to extend the knowledge of mechanical engineering science, in order to provide industry with the information that it requires for the solution of its own problems. In order therefore that its work may be focused on practical objectives of real value to industry, the Council have set up a Steering Committee, which comprises a number of distinguished engineers, to plan the laboratory's activities.

At the helm of the new Steering Committee will be Vice-Admiral Sir Frank Mason who is a member of the Research Council. Admiral Mason was Engineer-in-Chief of the Fleet until his retirement from the Royal Navy in 1957 and is now a director of Metal Industries Limited and of H. W. Kearns and Company Limited. The other members of the committee will be O. A. Saunders, Professor of mechanical engineering at Imperial College, University of London; N. Elce, Director and Chief Mechanical Engineer of Metropolitan-Vickers Electrical Company Limited; D. G. Sopwith, Director of the Mechanical Engineering Research Laboratory; C. M. Cawley, Director of Stations and Grants Division, DSIR.

The Committee's terms of reference will be (1) to be responsible to the Research Council for the selection of research projects and for the allocation of effort to them, within the financial resources allocated to the laboratory and other such limits as may from time to time be imposed by the Council; (2) to report annually to the Council, submitting a research programme for the following year.

To assist the Director, as the laboratory expands, and to improve the links between the laboratory and industry, two Deputy Directors have been nominated. They are Dr. S. P. Hutton and Mr. F. D. Penny. Dr. Hutton will have special responsibilities for fostering closer relationships with industry, and Mr. Penny for the management of the research programme.

MEETINGS AND PAPERS

Association of Supervising Electrical Engineers

LONDON
Various short papers by branch members. Central London Branch. White Hall Hotel, Bloomsbury Square, WC1. Mon., 4 May, 7.15 p.m.

MANCHESTER
Discussion on "Computers and Their Application in Industry." Manchester Branch. Engineers' Club, Albert Square, Manchester. Wed., 6 May, 7 p.m.

PRESTON
"Electric Clocks and Time Recorders," by E. O. Chapman. Preston Branch. RAFA Club, East View, Preston. Wed., 6 May, 7.30 p.m.

SHEFFIELD
"Kopp Variators," by N. S. Sellars. Sheffield Branch. Royal Victoria Hotel, Sheffield. Mon., 4 May, 7.30 p.m.

SOUTHAMPTON
"Strain Gauge and Blade Motions Recording Systems for Helicopters," by P. MacMahon. Southampton Branch. Polygon Hotel, Southampton. Thurs., 7 May, 8 p.m.

British Computer Society

LONDON
"Early Experience with an Electronic Data Processing Installation," by T. C. Hickman. Northampton College of Advanced Technology, St. John Street, EC1. Tues., 12 May, 6.15 p.m.*

British Institute of Radiology

LONDON
Annual General Meeting and Presidential Address, by Dr. J. Blair Hartley. Thurs., 7 May, 7.30 p.m.

British Institution of Radio Engineers

LONDON
"An Experimental Diode Parametric Amplifier and Its Properties," by I. M. Ross, C. P. Lea-Wilson, A. J. Monk and A. F. H. Thomson. London School of Hygiene and Tropical Medicine, Keppel Street, WC1. Tues., 5 May, 6.30 p.m.*
"Improving Communication Techniques; What Have Engineers to Learn from Information Theory," by Professor D. Gabor. London School of Hygiene and Tropical Medicine, Keppel Street, WC1. Wed., 13 May, 6.30 p.m.*

British Interplanetary Society

LONDON
"Inertial Guidance and Its Application to Astronautics," by D. J. Cashmore. Caxton Hall, off Victoria Street, SW1. Sat., 2 May, 6 p.m.*

Chemical Engineering Group

LONDON
"Fuel Economy in Chemical Works," by W. Quick. Tues., 12 May, 6 p.m.

Chemical Society

LONDON
Various original papers to be presented. Thurs., 7 May, 7.30 p.m.*

Engineers' Guild

CARDIFF
Luncheon Meeting. South Wales and Monmouthshire Branch. Old Arcade Inn, Church Street, Cardiff. Fri., 15 May, 12.45 p.m.

Faraday Society

LONDON
Bourke Lectures: "Surface Diffusion," by Dr. Robert Gomer (of the Institute for the Study of Metals, University of Chicago). Imperial College of Science and Technology, South Kensington, SW7. Mon., 4 May, 4.30 p.m. (Tickets *not* required.)

BELFAST
"Surface Diffusion" repeated. Department of Chemistry, Queen's University, David Keir Building, Stranmillis Road, Belfast. Wed., 6 May, 4.30 p.m. (Tickets *not* required.)

BRISTOL
"Surface Diffusion" repeated. Department of Chemistry, The University, Bristol. Fri., 8 May, 5.15 p.m. (Tickets *not* required.)

Helicopter Association

LONDON
"Helicopter Noise Suppression," by H. B. Irving. Royal Aeronautical Society, 4 Hamilton Place, W1. Fri., 8 May, 6 p.m.

Illuminating Engineering Society

CARDIFF
Open meeting for discussion of lighting problems. Cardiff Centre. Demonstration Theatre, South Wales Electricity Board, The Hayes, Cardiff. Thurs., 7 May, 6 p.m.

NOTTINGHAM
Annual General Meeting. Nottingham Centre. Electricity Service Centre, Nottingham. Thurs., 7 May, 6 p.m.

Institute of Petroleum

LONDON
Symposium on "Submarine Exploration for Oil," by members of BP Exploration Co., Ltd. Wed., 6 May, 5.30 p.m.*

Institute of Refrigeration

LONDON
"Cryogenic Liquids for Rocket Engines," by D. Hurden. Joint meeting with Physical Society. Institute of Marine Engineers, 76 Mark Lane, EC3. Thurs., 7 May, 5.30 p.m.*

Institute of Road Transport Engineers

CARDIFF
"Open Forum" Meeting. South Wales Centre. South Wales Institute of Engineers, Park Place, Cardiff. Fri., 8 May, 7 p.m.

LIVERPOOL
Annual General Meeting. West Regional Centre. Liverpool Architectural Society, Bluecoat Chambers, School Lane, Liverpool 1. Tues., 5 May, 7.30 p.m.

Institution of Civil Engineers

LONDON
Open Meeting. Tues., 5 May, 5.30 p.m.*

MANCHESTER
Annual General Meeting. North Western Association. Engineers' Club, Albert Square, Manchester. Thurs., 7 May, 6.30 p.m.

Institution of Electrical Engineers

LONDON
"Propagation of Electrical Signals Along Nerve Fibres," by Professor A. L. Hodgkin. Measurement and Control Section. Tues., 5 May, 5.30 p.m.*
"Lighting and Architecture," by J. M. Waldram. Utilization Section. Thurs., 7 May, 5.30 p.m.*
Discussion on "Microwave Radiation Hazards." Medical Electronics Group. Fri., 8 May, 6 p.m.*
Discussion on "Trends in the Teaching of Electric Machine Theory in the United States," opened by P. L. Alger. Education Discussion Circle. Mon., 11 May, 6 p.m.*
London Graduate and Student Section. Annual General Meeting, and Film Evening. Wed., 6 May, 6.30 p.m.*

ABERDEEN
Annual General Meeting. North Scotland Subcentre. Robert Gordon's Technical College, Aberdeen. Fri., 8 May, 7.30 p.m.

BELFAST
Annual General Meeting. Northern Ireland Centre. David Keir Building, Stranmillis Road, Belfast. Tues., 5 May, 6.30 p.m.

BIRMINGHAM
"Some Problems Associated with the Operation of Large Turbo-Alternators," by A. Abbott. South Midland Centre. James Watt Memorial Institute, Great Charles Street, Birmingham. Mon., 4 May, 6 p.m.*

EDINBURGH
Annual General Meeting. "Analogies," by D. K. Maclennan; and "Nurtured by NOSHEB: Preservation of the Highland Fish," by C. M. Beckett. South East Scotland Subcentre. Carlton Hotel, Edinburgh. Tues., 5 May, 7 p.m.*

GLASGOW
Annual General Meeting. South West Scotland Subcentre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C2. Wed., 6 May, 7 p.m.

LEEDS
Annual General Meeting. North Midland Centre. Offices of the Central Electricity Generating Board, Leeds. Tues., 5 May, 6.30 p.m.

MANCHESTER
Annual General Meeting. "Electrical Supplies to Power Centre. Engineers' Club, Albert Square, Manchester. Tues., 5 May, 6.15 p.m.*

Institution of Electronics

BIRMINGHAM
"Design of Transistor High-Frequency Amplifiers," by L. E. Jansson. Midlands Division. New College of Technology, Gosta Green, Birmingham 4. Fri., 8 May, 7 p.m.

Institution of Mining and Metallurgy

LONDON
Annual General Meeting: Report of Council and Statement of Accounts, at 4 p.m. Presidential Address on "Some Observations on Gold Refining and the Standard for Gold and Silver Coinage," by Dr. J. H. Watson, at 5.15 p.m.* Geological Society, Piccadilly, W1. Thurs., 21 May.

Institution of Public Health Engineers

LONDON
"Facts About Air Pollution from Homes and Factories," by R. L. Brown. Caxton Hall, off Victoria Street, SW1. Thurs., 14 May, 6 p.m.*

Institution of Structural Engineers

BIRMINGHAM
"Future Trends in Structural Engineering," by Professor S. C. Redshaw. Midland Counties Branch. Department of Civil Engineering, The University, Birmingham. Fri., 8 May, 10 a.m.

MIDDLESBROUGH
"Flat-Slab Concrete Structures," by J. A. Derrington; "The Future of Steel Single-Storey Buildings," by R. A. Sefton Jenkins; and "The Development of Foundation Engineering," by A. L. Little. Northern Counties Branch. Cleveland Scientific and Technical Institution, Middlesbrough. Fri., 8 May, 2 p.m.

Joint Committee on Structural Concrete

LONDON
"Ten Years Building Thin Shell Structures," by Felix Candela. Organised in association with the British Council. Friends' House, Euston Road, NW1. Tues., 5 May, 6 p.m. (Tickets, obtainable without charge, are required.)

Junior Institution of Engineers

LONDON
Twelfth Gustave Canet Memorial Lecture: Recent Developments in the Field of Heavy Steel Forgings," by Paul Gaston Bastien. Mon., 4 May, 7.30 p.m. (Tickets required.)

Leeds Metallurgical Society

LEEDS
Annual General Meeting. "Electric Melting Furnaces," by F. S. Leigh. Chemistry Wing, The University, Leeds 2. Thurs., 7 May, 7.15 p.m.

Physical Society

LONDON
"Cryogenic Liquids for Rocket Engines," by D. Hurden. Low Temperature Group. Joint meeting with the Institute of Refrigeration. Institute of Marine Engineers, 76 Mark Lane, EC3. Thurs., 7 May, 5.30 p.m.*

Royal Aeronautical Society

LONDON
"The Potential Use of Aircraft for Agricultural Purposes with Particular Reference to New Zealand," by R. H. Scott. Tues., 5 May, 7 p.m.

Royal Institution

LONDON
"The Modern State and Modern Society: Historic Tendencies and Future Probabilities," by Dr. G. Kitson Clark. Wed., 13 May, 9 p.m.

Royal Society

LONDON
Various short papers for reading and discussion. Thurs., 21 May, 4.30 p.m.*

Royal Society of Arts

LONDON
Trueman Wood Lecture on "The Growth and Scope of Industrial Design in the United States," by Walter Dorwin Teague. Wed., 6 May, 2.30 p.m.

Society of Chemical Industry

LONDON
Annual General Meeting, at 6.30 p.m. Chairman's Address on "Corrosion as a Design Problem," by Dr. S. G. Clarke, at 7.15 p.m. Corrosion Group. Wed., 6 May.

Society of Engineers

LONDON
"Grouting and Civil Engineering," by D. J. Ayres. Geological Society, Burlington House, Piccadilly, W1. Mon., 4 May, 5.30 p.m.*

Society of Instrument Technology

LONDON
Annual General Meeting, at 5.30 p.m.* Presidential Address, at 6.30 p.m. Manson House, Portland Place, W1. Wed., 6 May.
Annual General Meeting of the Data Processing Section. "A Multipoint Digital Strain-Gauge Recorder," by J. R. Sturgeon. Manson House, Portland Place, W1. Wed., 13 May, 6 p.m.*

MANCHESTER
Annual General Meeting. "Temperature Measurement with Resistance Thermometers," by C. K. Massey. Manchester Section. Central Library, St. Peter's Square, Manchester 1. Tues., 12 May, 6.30 p.m.

South Wales Institute of Engineers

CARDIFF
Paper on "Switchgear." Thurs., 14 May. (This meeting has been cancelled.)

Southampton Metallurgical Society

SOUTHAMPTON
Annual General Meeting followed by a social function. Small Physics Lecture Theatre, The University, Southampton. Thurs., 7 May, 7.15 p.m.

Television Society

LONDON
Annual General Meeting. Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, WC2. Fri., 8 May, 7 p.m.

Women's Engineering Society

LONDON
Discussion on "Aerial Survey Methods." Hope House, 45 Great Peter Street, Westminster, SW1. Thurs., 21 May, 7 p.m.*

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this feature should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, WC1. (LANgham 5927.)
British Computer Society, Finsbury Court, Finsbury Pavement, London, EC2. (MONarch 6252.)
British Institute of Radiology, 32 Welbeck Street, London, W1. (WELbeck 6237.)
British Institution of Radio Engineers, 9 Bedford Square, London, WC1. (MUSeum 1901.)
British Interplanetary Society, 12 Bessborough Gardens, London, SW1. (TATe Gallery 9371.)
Chemical Engineering Group, 14 Belgrave Square, London, SW1. (BELgravia 3647.)
Chemical Society, Burlington House, Piccadilly, London, W1. (REGent 0675.)
Engineers' Guild, 78 Buckingham Gate, London, SW1. (ABBey 7315.)
Faraday Society, 6 Gray's Inn Square, London, WC1. (CHAncery 8101.)
Helicopter Association of Great Britain, 4 The Sanctuary, London, SW1. (ABBey 5160.)
Illuminating Engineering Society, 32 Victoria Street, London, SW1. (ABBey 5215.)
Institute of Petroleum, 61 New Cavendish Street, London, W1. (LANgham 3583.)
Institute of Refrigeration, New Bridge Street House, New Bridge Street, London, EC4. (CENtral 4694.)
Institute of Road Transport Engineers, 69 Victoria Street, London, SW1. (ABBey 6248.)
Institution of Civil Engineers, Great George Street, London, SW1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. (TEMple Bar 7676.)
Institution of Electronics, 78 Shaw Road, Thornham, Rochdale, Lancs. (Oldham Main 6661.)
Institution of Mining and Metallurgy, 44 Portland Place, London, W1. (LANgham 3802.)
Institution of Public Health Engineers, c/o The Portman Building Society, 39 Portman Square, London, W1.
Institution of Structural Engineers, 11 Upper Belgrave Street, London, SW1. (SLOane 7128.)
Joint Committee on Structural Concrete, Terminal House, Grosvenor Gardens, London, SW1.
Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, SW1. (VICtoria 0786.)
Leeds Metallurgical Society. Apply to Dr. P. Feltham, The University, Leeds.
Physical Society, 1 Lowther Gardens, South Kensington, London, SW7. (KENsington 0048.)
Royal Aeronautical Society, 4 Hamilton Place, London, W1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle Street, London, W1. (HYDe Park 0669.)
Royal Society, Burlington House, Piccadilly, London, W1. (REGent 3335.)
Royal Society of Arts, John Adam Street, Adelphi, London, WC2. (TRAfalgar 2366.)
Society of Chemical Industry, 14 Belgrave Square, London, SW1. (BELgravia 3681.)
Society of Engineers, Abbey House, Victoria Street, London, SW1. (ABBey 7244.)
Society of Instrument Technology, 20 Queen Anne Street, London, W1. (LANgham 4251.)
South Wales Institute of Engineers, Park Place, Cardiff. (Cardiff 23296.)
Southampton Metallurgical Society. Apply to Mr. S. W. Hallwood, Folland Aircraft Ltd., King's Avenue, Hamble, Hants.
Television Society, 166 Shaftesbury Avenue, London, WC2. (TEMple Bar 3330.)
Women's Engineering Society, 25 Foubert's Place, London, W1. (GERrard 5212.)

On the Shelf

By Frank H. Smith

Some interesting figures are given in *Soviet News* of 25 March. The USSR State Library of Foreign Literature's English collection includes more than 100,000 volumes. Of these, 3,000 were received in 1958, and about 400 different periodicals have been ordered from Britain for the current year. Twenty-one British organisations, institutions, societies and universities exchange books. And our booksellers still complain and imply they've been sold up the pass.

A firm called Computer Consultants Limited, of Hirnant, Dolgelley, realises that managment does not always appreciate the finer points of highly technical apparatus and they are therefore bringing out (in April) a *British Commercial Computer Bulletin* which " will give a comprehensive survey of what is available on the market." Three guineas a copy. It will not tell management whether they should use a computer and if so how and where—that remains the province of the firm producing the bulletin —but presumably if you have a sneaking idea that computers are a Good Thing, you buy the bulletin to see if they can be used and what they can be used for and you then go ahead from there. Twenty-one manufacturers have been consulted.

The latest *LLU Translations Bulletin* announces the start of a collection of Chinese scientific literature and 150 periodicals are already being taken. A few Chinese characters are splattered over the bulletin to show what they are up against. A few of those periodicals cut up and plastered over the wall would make a very nice contemporary wallpaper.

A publisher's circular from France is so well done in the English idiom and style that I have looked closely but in vain for an English agent. Publicité et Éditions Techniques of 1 Rue du Drabon, Paris 6e, announce " Guide Technique de l'Electronique Professionelle (Le Buyer's Guide Francais) "; 1,100 pages, in four languages, 2 volumes, 5,500 francs. That Buyer's Guide bit spoils it and reminds me of a restaurant I saw in Knightsbridge with the notice " Chinese Cuisine"'

I have rather long reprint from *Industrial Photography* (January) extolling the virtues of a 105 mm microfilm service covering the US Atomic Energy Commission drawings, among others. If you are interested drop a line to Jim Goodspeed at Cooper-Trent Blueprint and Microfilm Corp. at Arlington, Va., USA.

On 20 February, little Frankie boobed slightly in his references to film. *Film News* is a quarterly publication issued by G.B. Film Library, so my crack about April, 1958, was unfair. Those industrial films that I mentioned in the same paragraph are now available from the G.B. Film Library at general hire prices. The address is 37-41 Mortimer Street, London, W1 (MUSeum 5432).

Repercussions from items in this column can give me great delight. For instance, on page 411 I cracked at a mixture of Wiener-Hopf and Weiner-Hopf, whereupon a kind correspondent wrote to tell me that *The Organization Man* is credited with an author named Whyte on the dustcover and White on the title page. As he says, somebody should get organised. But the real beauty of the joke is that my informant is on the staff of Thomas Hedley and Company Limited, and what they do not know of what makes white white would go on a (Fairey) soap flake.

The Stationery Office list of Government publications for February (received on 1 April) includes " The Structure of the Public Library Service in England and Wales," at 3*s* 6*d* plus 4*d* postage. Another interesting (and morbid) title is " The Length of Working Life of Males in Great Britain " at the same price. I can't help feeling that there's scope for a remark like " About 5 per cent " here but it escapes me for the moment.

BOOLEAN BASIS

Switching Circuits—With Computer Applications. By WATTS S. HUMPHREY, JR. *McGraw-Hill Book Company Incorporated, 330 West 42nd Street, New York 36, NY, USA.* and *McGraw-Hill Publishing Company Limited, 95 Farringdon Street, London, EC4* (66*s*)

It is usual for books dealing with the design of electronic digital computers to give an account of Boolean algebra and its applications to the subject of circuit design. In spite of this it is common, in England at least, to find a slightly cynical and rather disillusioned attitude to the subject among design engineers. The usual comment is that this technique is only useful in extremely simple cases or that it is normally quicker to work by intuitive methods. Some engineers admit that it is useful as a check, but consider that it is of no help in circuit design. Probably the reason for this is that, although the subject is usually adequately explained, insufficient attention is paid to the application of it and few engineers have the patience or time to experiment with it further.

In so far as this book deals with Boolean algebra a great deal of space is devoted to practical applications with a large number of worked examples to illustrate the technique. Furthermore, the subject is developed to a more advanced level than in most textbooks—a whole chapter being devoted to Boolean matrices and their applications. The style is pleasant and very readable, but it is essential to read the book from the very beginning. Individual chapters cannot be easily understood if read in isolation. The author, who is a university teacher as well as a practical engineer, treats his material in a very fundamental manner. After reading a chapter one is left with the impression of a field whic! still has much to explore, and at the same time of having the necessary tools to pursue the matter oneself.

Although intended as the subject of a post-graduate course the standard of knowledge for understanding the book is not much greater than that of a first year engineering student, although he will probably find the subject matter in the latter part of the book rather difficult. A graduate in either engineering or mathematics should find little difficulty since such mathematics as is used is clearly explained and electronic components of basic circuits are dealt with in an elementary manner.

After dealing with the basic principles of Boolean algebra the subject of relay networks is covered. The approach is to produce simple but practical logical design problems which are attacked from first principles and a solution found in terms of algebra. This leads, naturally, to the problem of minimising the algebra expression in a given case so as to reduce the complexity of the corresponding circuit. The subject of minimising by various means is dealt with fully and much use is made of Karnaugh maps, which are fully explained since they are used in numerous applications at later stages in the book.

The subject of codes is treated from first principles and the efficacy of various codes in error detection is discussed in some detail. It is surprising to find how many possibilities of coding exist and this seems to be a field well worth further investigation. The ground work in this work is an ample basis for anyone who wishes to explore the matter further.

The rest of the book deals with applications to circuit logic, including systems making use of diodes, transistors and relays. The subject of Boolean matrices is then developed and this leads, naturally, to the design of bilateral networks and systems involving the use of magnetic cores. The book ends with the treatment of cascading circuits and the design of sequential circuits in which an output only occurs after a predetermined sequence has passed the input.

There is a fairly extensive list of references, nearly all of them from American publications, and also an adequate index. A feature of the book is a large number of examples at the end of each chapter. Although most of these take the form of having to prove some statement, some do not. It seems a pity that a set of answers have not been provided for these problems as they are well worth doing—but this is a very minor criticism.

F. L. WESTWATER

ONE DIMENSIONAL MODEL

Thermodynamics of Fluid Flow. By NEWMAN A. HALL. *Longmans, Green and Company Limited. 6 and 7 Clifford Street, London, W1* (32*s* 6*d*)

In analysing many problems of flow in ducts, the assumption that the flow is one dimensional is often a useful approximation. At first sight this is surprising, since the flow model which forms the basis of the one-dimensional method differs profoundly from the actual physical situation. For instance the existence, due to the boundary layer, of a non-uniform and possibly changing velocity profile is ignored, and happenings at the walls of the duct, for example friction, are assumed to be felt instantaneously over the whole cross-section. Nevertheless, there are many situations of importance in engineering where the one-dimensional method may be used with good accuracy.

Where flow in ducts is concerned, the requirements are firstly that changes of area occur only slowly, so that velocity components at right angles to the centre-line are negligible, and secondly that the distributions of velocity, temperature and other properties across the duct, although not necessarily uniform, are at least unchanging. Under these circumstances the one-dimensional method deals in fact with certain mean values of flow parameters, which are then functions of distance along the centre-line only. Apart from flow in ducts, however, the assumption of a one-dimensional flow model is strictly valid for infinitesimal stream tubes, across which in the limit, the distributions of all flow parameters must of necessity be uniform. Furthermore the method, by its very simplicity, is a powerful tool for gaining a preliminary insight into a wide range of problems, and in the last resort it may almost be said to be justified by this simplicity.

The fact that thermodynamics has a large part to play, even in the absence of deliberate heat or work transfer, stems from the inter-relationship which exists for gases, and to a certain extent for liquids, between pressure, density and temperature. Thus fluid acceleration, involved for instance when the area available for flow changes, is usually produced by differences in pressure. In general therefore density changes must occur. The combined effects cause a change of temperature and thermal effects are involved, the study of which involves the laws of thermodynamics.

Thermodynamics of Fluid Flow gives a clear, concise and logical introduction to the theory of the steady flow of fluids in one-dimension. A clear summary of the laws and a review of units and dimensions and fluid properties forms an introductory chapter. The system of units (*lbf, lbm, ft, s*) is adopted; this requires the use of the symbol g_c as the constant in Newton's second law of motion and has much to recommend it for clarity, generality, and for the avoidance of the all-too-familiar pitfalls associated with the misuse of " g."

The chapter on fluid friction which follows,

gives a review of laminar and turbulent flow of liquids in pipes and of the associated losses. Up to this point the material covered should be largely familiar to those who have taken introductory courses in incompressible fluid mechanics and in thermodynamics. This in fact sets the prerequisite standard for this book, which most effectively marries the thermodynamical and mechanical aspects of fluid motion.

The fundamental equations of continuity, momentum and energy for steady flow in one dimension are next established. The second law of thermodynamics is then invoked to relate entropy increases and losses, and thereby to establish the concept of loss on a logical footing and to put all types of losses, whether due to wall friction, drag of internal objects or turbulent separation, on a common footing. It is hoped that so excellent a combination of rigour and readability will in the future be always to be found in the development of these all-important fundamental equations; such could not be said of so many books in this field in the past.

So far the equations are generally applicable to any type of fluid undergoing any type of process. The remainder of the book deals with the application of the general equations to particular types of fluids undergoing particular types of flow processes. The particular types of fluid for which explicit formulae are obtained are incompressible fluids and perfect gases, although the method applicable to the general fluid, which belongs to neither of these categories, is considered whenever appropriate.

A distinction is drawn between constant density incompressible fluids and those for which the density may vary with temperature but still remain independent of pressure. Discussion of the behaviour of the latter type of fluid is rarely found and is an interesting and useful feature of the book. The flow processes considered are respectively constant-area adiabatic flow, varying area adiabatic flow and diabatic flow. In this way the individual and combined effects of friction, area change and heat transfer are presented. There are additional chapters dealing with shock regions, flow measurement and control, and propulsion systems. There are a large number of problems, which include both drill problems and those serving to extend the theory presented in the text. In addition the appendix contains a useful collection of data and tables, including a generous selection of the well-known and much used one-dimensional flow functions compiled by A. H. Shapiro and his associates.

First published in the USA in 1951, this book has already established its reputation in this country. It is thoroughly to be recommended as a first-rate introduction to the combined field of thermodynamics and fluid mechanics.

R. D. TYLER

SYSTEMATIC DIAGNOSIS

Engineering Systems Analysis. By ROBERT L. SUTHERLAND. *Addison-Wesley Publishing Company Incorporated, Reading, Massachusetts, USA*; and *Academic Books Limited, 129 Queensway, London, W2* (60*s*)

Far too many young graduates leave their universities each year unable to distinguish the wood from the trees in what they have been taught. Partly this is due to the undue emphasis upon solving problems rather than finding out what are the problems to be solved; partly to the subdivision of subjects; and partly to the tendency to continue discussion of problems which are no longer of great interest in themselves, however valuable they may be as means of instruction.

This book is an attempt to get round these difficulties. The author starts by discussing for more than half the book the similarity between the methods of analysis used in a wide range of problems, and in particular he concentrates on the analysis of simple mechanical, electrical and acoustic vibrational systems, and also combined systems such as loud speakers. This takes more than half the book; it is lucid and easy to read, and exactly what many men need. Its main weakness lies in a neglect of the usefulness of vector diagrams and loci for illustrating the relationships involved, and also of a comparison of the mechanical engineer's "damping ratio" with the electrical engineer's "Q factor," although both are used.

A chapter on dimensional analysis is somewhat thin, but the remaining quarter of the book offers an admirable elementary introduction to analogue and digital computers, starting with a very simple discussion of certain elementary aspects of feedback and control, and proceeding to show the principles of both differential analysers and of digital devices. The treatment of the latter might well have been expanded lightly, but the examples on computation at the end of the book could scarcely be bettered. A graduate who could work these accurately would be able to think far more logically than one who could merely solve accurately the limited range of differential equations which yield to standard tricks. School and university engineering degree mathematics have tended to get bogged down in the teachng of branches of the subject which intrigued the mathematicians of the last century, and many young engineers are put off by it; this chapter may help to arouse interest once more, besides introducing them to one of the new and exciting ways of using machines to extend the capacities of their brains.

The advantages and disadvantages of this book lie in its expressed intention of being a course-book for American universities. One day the author may write something of greater depth; meanwhile, most final year undergraduates and many practising engineers will gain much from reading this book.

D. B. WELBOURN

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Miscellaneous

Selsyns. BRITISH THOMSON-HOUSTON CO. LTD., Rugby. "Selsyns—their performance and operation," by S. A. Choudhury; a lecture-service publication available to professional engineers.

Technical Publications. HAYWARD AND MARTIN LTD., 34 High Street, Bromley, Kent. A service of authorship, illustrations, diagrams, photography, etc., for technical material.

Consultants. NORRIS BROTHERS LTD., Burgess Hill, Sussex. Brochure describes tooling, test rigs, "Bluebird" and electronic designs by the firm.

New Factory. TEXAS INSTRUMENTS LTD., Dallas Road, Bedford. Colour booklet gives details of the plant recently opened by the American parent company at Dallas, Texas, USA.

Automation. ELLIOTT-AUTOMATION LTD., Century Works, Lewisham, London, SE13. Examples of the group's operations are given in a 40 page booklet.

Protection

Metal Primer. ALLWEATHER PAINTS LTD., 36 Great Queen Street, London, WC2. "Pitan" metal conditioner for non-ferrous metal surfaces. Non-toxic adhesive film combining etching primer and corrosion inhibitor. Leaflet.

Cathodic Protection. F. A. HUGHES & CO. LTD., Devonshire House, Mayfair Place, Piccadilly, London, W1. "Guardion" cathodic protection for deep tanks and external hulls. Examples of use given in brochures Nos. 94 and 95.

The Reviewers

Mr. F. L. Westwater, O.B.E., M.A., A.M.I.E.E., has been deputy manager of the research and design division of the British Tabulating Machine Company, Limited, which is now undergoing reorganisation following its incorporation in the new company, ICT Limited. Mr. Westwater is an M.A. of Edinburgh University, obtaining first class honours in mathematics and natural philosophy, and an M.A. of Cambridge where he achieved the distinction of wrangler in the mathematics tripos. After serving with the Royal Navy from 1935 to 1958, he retired with the rank of Captain.

Dr. R. D. Tyler is at present head of the mechanics of fluids group in the mechanical engineering laboratories of the English Electric Company at Whetstone. He is a Ph.D. and an A.M.I.Mech.E. and was until recently a lecturer in mechanical engineering at Imperial College of Science and Technology, University of London. Previously he had held the post of assistant professor at the Massachusetts Institute of Technology under the Fulbright scheme.

Mr. D. B. Welbourn, M.A., M.I.Mech.E., is a lecturer in the department of engineering, University of Cambridge, where he earlier received his academic education. Following a graduate apprenticeship with the English Electric Company, he became assistant to the works superintendant at Stafford and in 1942 entered the Royal Navy. Demobilised in 1946 with the rank of Lieutenant Commander R.N.V.R., he joined W. H. Allen Sons and Company as development engineer, and became the first manager of their epicyclic gears department. He also served with Turners Asbestos Cement Company from 1950 to 1952, when he returned to Cambridge as lecturer. He is a fellow and director of studies at Selwyn College, a member of Council of the Institution of Electrical Engineers, and has been a member of a Ministry of Supply committee on automatic control problems. He is a member of the Verein Deutscher Ingenieure.

NEW BOOKS

Die Korrosionsbedingten Ermudüngsbrüche der Pleuelstangen bei Gattersägen. (Fatigue Failures of the Connecting Rods of Frame Saws Under Corrosion). By JAAKKO SALOKANGAS. Mechanical Engineering Series 4. *Acta Polytechnica Scandinavica Publishing office, Box 5073, Stockholm 5, Sweden;* and Publication No. 43 of *The State Institute for Technical Research, Helsinki, Finland.* (*Sw. Kr.* 7·00)

The Autocorrelation Function and the Power Spectrum of Nonstationary Shot Noise. By L. P. HYVÄRINEN. Electrical Engineering Series No. 2. *Acta Polytechnica Scandinavica Publishing office, Box 5073, Stockholm 5, Sweden;* and Publication No. 46 of *The State Institute for Technical Research, Helsinki, Finland.* (*Sw. Kr.* 7·00)

Interstitial Patterns. Defence Standards Laboratories Technical Note 50. By A. J. C. HALL and J. G. HAYES. *Australian Defence Scientific Service, Maribyrnong, Victoria.*

Tables for Bivariate Oslculatory Interpolation Over a Cartesian Grid. By HERBERT E. SALZER and GENEVIEVE M. KIMBRO. *Convair-Astronautics, San Diego, California.*

Science News 50. Edited by ARCHIE and NAN CLOW. *Penguin Books, Harmondsworth, Middlesex.* (2*s* 6*d*)

The current number of the well known quarterly publication *Science News* opens with an account of the voyages of HMS Beagle, of timely interest in connection with the recent Darwin celebrations. Recent developments in physics are covered in articles on cyclotron resonance and on the Maser, the low noise characteristics of which are likely to result in improved reception in radioastronomy. Biochemistry is the theme of the article entitled "A Sceptical Chemist" and further advances in the same subject are reviewed in "The Metabolism of Drugs and other Foreign Organic Compounds." "Inductive Methods in Palaeontology" are described in broad outline by Dr. Swinton and Mr. Haslett's "Research Report" presents items of interest ranging from phons and sones to meteorite craters. Sixteen illustrations and numerous line diagrams help to clarify the text and a number of book reviews are included.

EPOXY ROAD COATINGS

Epoxy resins have been developed in the United States for application to many types of road surfaces and, to date, encouraging reports have been received of the life of the coatings and their suitability for safe, fast driving.

The material provides protection for the road from water, de-icing salts, and freezing and thawing in winter weather, and as the layer is in the region of $\frac{1}{8}$ to $\frac{1}{4}$ in thick it is comparatively light in weight; where lightness is paramount, such as on bridge surfaces, the greater expense compared with bituminous road coatings is fully justified.

This resinous cement is based on a liquid epoxy resin which, on the addition of a curing agent, sets up as a hard solid. Unlike many of the present surfacing materials this new product does not flow at elevated temperatures nor will it soften even after long periods of exposure to petrol, diesel fuel or motor oil. It exhibits adhesive, compressive, shear and tensile strengths greatly exceeding those of conventional cements and, being non-porous, is highly resistant to water and a wide range of chemicals.

The product which provides the basis of this surfacing material is a recently developed class of resins marketed by Shell Chemical Corporation in the United States, under the trade name Epon, and by Shell Chemical Company in the United Kingdom under the trade name Epikote. The wide use which these resins have achieved in many fields is attributed to the fact that they possess many desirable characteristics, including excellent adhesion, good chemical resistance and toughness, and that they cure rapidly at normal temperatures.

These properties, which have placed the "Epikote" resins in the forefront of the paint, varnish and plastics industries, also make them an ideal material for road surfacing compositions.

In the early days laboratory experiments were carried out on mixtures of epoxy resins and aggregate, in order to determine the proper type and particle size distribution of aggregate to give the best results. Investigation showed that the coefficient of friction to rubber (tyre) both dry and wet of such a mix was much higher than the friction coefficient of rubber to concrete. Moreover the adhesion to all road paving materials was higher than the substrate's adhesion to itself. The encouraging laboratory results obtained led to the application of test patches on various busy roads and bridges in the United States. Three large sized development patches were applied to concrete in 1955. At a Connecticut toll booth, 12,000 sq. ft were applied where skidding accidents were frequent; at Harrisburgh, Pennsylvania, a 10,000 sq. ft bridge with a worn concrete surface was treated to give a smooth non-skid surface; at Perryville, Maryland, an area of 1,100 sq. ft at a toll gate area was surfaced. After a year's use some adhesion failures had taken place which were traced to unsuitable pre-cleaning treatment of the road surfaces. Following an investigation into this aspect of the problem and a modification in the procedure, the trouble was overcome.

In applying this type of surfacing material two methods are generally used, in both of which the "Epikote" resin binder is first mixed with curing agent. Where the area to be surfaced is relatively smooth and where only a thin layer is required, the catalysed resin containing no filler is thinly spread over the cleaned road surface and the sand or other filler is subsequently distributed thinly over the resin layer, the excess being finally brushed off.

Alternatively, in the second method, where holes and deep irregularities must be filled to obtain a smooth surface, the catalysed resin is pre-mixed with sand to obtain a "mortar" which is then trowelled on to the surface to fill the irregularities.

Re-surfacing with Portland cement or rolled asphalt generally necessitates the use of layers of such considerable thickness as to require the raising of manholes, drains and pavements. On bridges, expansion joints are similarly affected and in some cases an excessive dead weight layer may be added when a thick re-surfacing material is applied. Because of the comparatively light weight of the very thin layers used, this new material is proving of great interest in the surfacing of bridges.

No practical tests have been carried out with this material by Shell Chemicals in the UK, but the firm is now investigating the field.

VITREOUS ENAMELLED ALUMINIUM

In March of this year the London branch of the Vitreous Enamel Development Council opened new offices in Welbeck Street; their role, to make the public more aware of what vitreous enamelling is and what it can do, to promote its application and to protect users by establishing minimum manufacturing standards.

Vitreous means "glass-like," and vitreous enamels are glass-like—hard, glossy, corrosion resistant and brittle. But what a pity they are brittle—everybody must have seen chipped enamel on cooking holloware and the unsightliness of the black undercoat.

If vitreous enamelling loses popularity, it will do so over the dead body of the Development Council—but where is it going to survive? Perhaps architecture is one answer. Look now at the application of vitreous enamelling to aluminium. Many firms have attempted to enamel aluminium, the main difficulty—low adherence and brittleness. Ferro Enamels Company have now, however, produced a series of lead-free frits, and Ernest Stevens Limited of Cradley Heath, Staffordshire, are applying them to aluminium to produce a product known as Judgelite.

Balconies in this block of flats are trimmed with vitreous enamelled aluminium in greenish-blue and pale yellow.

The company has taken a progressive step by introducing, for the home handyman, vitreous enamelled aluminium tiles for kitchens and bathrooms. The tiles, which are available in a wide range of colours are pressed from 22 gauge sheet to a size of 4 in square. Many attempts at internal decoration may be lucky to escape notice, but the appearance of these tiles is undoubtedly attractive.

Quite apart from their standard tiles, Ernest Stevens will apply Judgelite finish to most aluminium alloy surfaces at a cost of very roughly 6*s* per sq. ft. In sheet, pure aluminium or $1\frac{1}{4}$ per cent manganese alloys are readily coated; in castings, LM6 and LM18 are best suited; in extrusions successful finishes can be achieved on a number of alloys.

Following caustic soda and nitric acid pretreatment and preheating, an oxide film is built up to which sprayed enamel bonds strongly during fusion at about 540° C. The resultant coatings are thin and are sufficiently adherent to allow cutting, drilling, nailing or punching without noticeable flaking.

Dolphin Court is the name of a new block of flats in Hove—flats whose balconies are trimmed with enamelled aluminium to the design, as illustrated, of the architects—Morgan and Carn of Hove. They had 150 colours to choose from, varying from full gloss to matt finish, and they chose greenish-blue and pale yellow with a high lustre.

Judgelite vitreous enamelled aluminium is manufactured to standards laid down by the Porecelain Enamel Institute of the United States No. ALS-105 (57). In America the material has been widely accepted for architectural uses. Is a similar distinction going to be the destiny of vitreous enamelling in this country?

MOISTURE COMBATTING PLASTERS

If you are suffering from mould growth, fungus or condensation take note; Voboma 68 and Voboma 34 have been introduced into this country by British Lead Mills Limited, of 7 St. James's Street, London, SW1. These materials, when mixed with cement and lime, yield plasters which are porous and insulative, but while 68 is water repellent, 34 can absorb 70 per cent of its own volume of moisture. 68 is said to be especially useful in restoration of old churches and castles where it combats rising and penetrating damp. Two coatings $\frac{1}{4}$ in thick are required. These are applied over a surface which has been rendered with a cement-lime-sand mortar and from which, in the words of the makers, "existing plaster has been hacked off." 34 combats condensation by absorption and fast evaporation of moisture—ideal for piggeries, paper mills, swimming baths and waterworks. The application procedure is similar to that for 68. Both plasters have already proved themselves on the Continent.

FIRTH BROWN FILMED

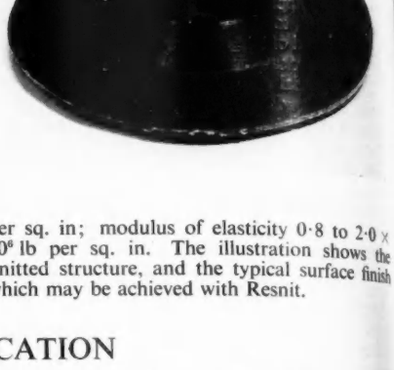
The workings triumphant of Thomas Firth and John Brown—the alloy steelmakers of Sheffield—have been recorded on 1,200 ft of colour film.

The film deals in a pleasant and informative way with the activities and products of this well-known firm, and it would form a useful addition to any programme. Fortunately there is more than one copy of the film—called "Tour of the Works"—and they are available for loan to schools, institutions and persons.

MOULDABLE REINFORCED PLASTICS SHEET

On to the general market has now come a mouldable reinforced plastics sheet called Resnit, made by Leicester, Lovell and Company Limited, of North Baddesley, Southampton. Although impregnated sheet is a material which has appeared regularly at half-way stages in the manufacture of reinforced mouldings, this material has not been generally available; some interest has, however, been aroused at the thought of a reinforced sheet to replace steel for such parts as pressed car bodies. The main drawbacks envisaged for such a sheet are first its cost of at least double that of steel, second that once cured such sheet has little scrap value, as with thermosetting resins remelting and softening is impossible, and third that the moulding and setting cycle normally takes tens of minutes. How does the new material stand-up for itself?—it is still initially expensive compared with steel, and cured scrap cannot be reclaimed. However, the curing cycle has been reduced to 1½ to 2 minutes at 100 to 500 lb per sq. in and 160° C, and there is a real prospect of greatly reducing this by "shock curing," pressings having been cured on a laboratory scale in as little as 6 seconds. If blanked before pressing, uncured sheet may, of course, be re-used as sheet or as dough moulding material.

The reinforcement of Resnit is knitted, and allows stretch in three dimensions to form shapes which could only be made with difficulty, or not at all, in sheet metal. For applications where a high degree of chemical resistance or dimensional stability is needed, the cellulosic fibre can be replaced by glass or synthetic materials. Normally, the following properties are attained: density, 1·5; flexural strength, 10 to 30,000 lb per sq. in; modulus of elasticity 0·8 to 2·0 × 10^6 lb per sq. in. The illustration shows the knitted structure, and the typical surface finish which may be achieved with Resnit.



DESULPHURISATION IN LURGI GASIFICATION

A new type of tower purifier installation never before used in Britain will be incorporated in the Lurgi pressure gasification plant which the Scottish Gas Board are building at Westfield on the border of Fife and Kinross.

The purifiers—with a capacity of 30 million cu. ft of gas per day—are of the Bischoff type for high pressure operation. This system eliminates the large number of valves usually associated with oxide purification systems, and oxide handling is fully mechanised to reduce labour requirements.

In all gas manufacturing systems designed for the production of town gas, the crude gas has to pass through various purification processes which remove certain chemical constituents. In high-pressure gasification by the Lurgi process, hydrogen sulphide is removed at two different points in the stream. Most of it is removed when the gas passes through a Benfield washing plant, but the primary purpose of the Benfield plant is to remove carbon dioxide which is present in larger quantities in the Lurgi process than in conventional systems; it is to remove the remaining traces of hydrogen sulphide that the Bischoff tower purifiers are being installed.

The installation visualised for the Scottish Gas Board's plant will comprise two parallel streams of four high-pressure tower purifiers and will operate at a pressure of more than 300lb per sq. in, each purifier containing a number of trays filled with a mixture of oxide of iron. Normally gas will pass through both streams, but at fixed intervals of about 21 days the gas will be shut off one stream, all the gas passing temporarily through the other. Rotation of the oxide in relation to the towers is a patented feature of the Bischoff system. Stocking towers, in which trays of oxide will be stored during the emptying and filling operations, are provided.

The contract for building the purifiers has been awarded by the Scottish Gas Board and Humphreys and Glasgow Limited—the main contractors for the erection of the works—to Newton Chambers and Company Limited, of Thorncliffe, near Sheffield. The cost of the installation will be about £150,000.

READY MIXED PLASTICS FOR TOOLING

Plastics tools and moulds are basically inexpensive in material and fabrication costs; the raw materials, however, require mixing of usually more than two components, at which stage inaccuracies and inconsistencies can arise. Kenilworth Manufacturing Company Limited, West Drayton, Middlesex, are now making a range of two component mixes; incorporated in the hardener component of each of these is a coloured dye which gives a visual indication when perfect mixing has been attained. Ten grades are made which vary from low viscosity systems for use with glass cloth reinforcement, to thixotropic pastes and putties. Most of these harden in 24 to 48 hours.

Tensile, compression and impac tstrengths may be high, metal inserts bond strongly to the resins, and modifications of design are readily carried out by cutting out or building up on existing surfaces.

Users of these resins will normally need to be armed with a release agent and a hard-facing resin, on which complete information is offered by the manufacturers.

NEW BERYLLIUM COPPER ALLOY

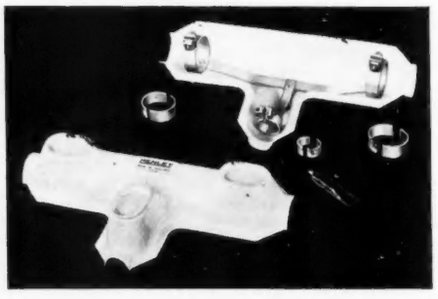
With a beryllium content of about 1 per cent, a new alloy made by Beryllium Smelting Corporation in the United States is attractively complementary to the existing 2 per cent alloys both in that country and in the United Kingdom. It has been termed Beryldur, and has properties outlined in the table. In the heat-treatable condition the alloy can be severely worked and treated to give a yield strength of 105 to 125,000 lb per sq. in; mill hardened strip allows mild forming, requires no heat-treatment, but has the lower yield strength, as supplied, of 95 to 115,000 lb per sq. in. Fatigue strength of these beryllium alloys is good, and this, combined with high yield strength, wear and corrosion resistance, makes them well-suited for electrical spring and contactor parts. Beryldur is marketed in this country by Beryllium Smelting Corporation Limited, 36-38 Southampton Street, London, WC2.

Condition	Yield strength, lb per sq. in	Elongation on 2 in per cent	Electrical conductivity per cent IACS
Heat-treatable (as supplied)	18,30,000	40-60	18-22
Heat-treated (650° F, 4-5 hr)	105-125,000	12-20	22-26
Mill-hardened (as supplied)	95-115,000	15-22	22-26

PLASTICS JOINT BOXES

W. T. Henley's Telegraph Works Company Limited, 51-53 Hatton Garden, London, EC1, have designed a range of joint boxes manufactured from pvc in which a cold-filling compound is used. The range comprises straight through, service and branch boxes for cables up to 0·30 sq. in. The boxes are moulded from pvc sheet in two halves which are stuck together with adhesive to form a complete shell. The top half is provided with compound filling holes with press-in covers.

For straight through and branch joints, Henley's recommend sweated type connections, but for service joints a new type of mechanical connector has been developed which dispenses with the use of solder and heat. To ensure continuity of the armouring, copper bonds with combined clamping rings, which securely grip the armouring wires, are supplied. Henley's make a cold-filling compound which is suitable for filling the boxes. This adheres effectively to both the pvc insulated cores and to the pvc box itself.



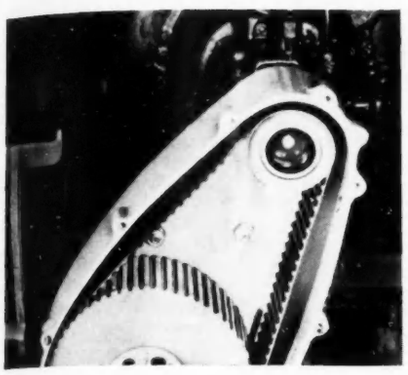
DIAMOND GRIT

The address of the Diamond Tool Research Co. Incorporated, from whom may be obtained supplies of an improved grit, is 580 5th Avenue, New York 36, NY, USA, and not at 4th Avenue, as was given in this section of the 6 March issue of the journal.

NON-SLIP DRIVE ELIMINATES WHEELSPIN

The new diesel dumper manufactured by C. H. Johnson (Machinery) Limited, Stockport, is the first to employ the US Powergrip timing belt in the transmission. Powergrip, which has hitherto been employed mainly in industrial machinery drives, is manufactured by the North British Rubber Company, Edinburgh, an affiliate of the United States Rubber Company.

The new Johnson "One-20" dumper is powered by a 6·3 b.h.p. Lister air-cooled diesel engine. It has an articulated chassis arranged to provide a combination of stability and manoeuvrability. A rear wheel drive is employed



for maximum traction, reducing wheel spin under all conditions of loading. It is here that the introduction of the Powergrip timing belt has permitted improved working, operating from the output shaft of the gearbox directly on to the differential.

The belt, of tough Neoprene construction, has a steel cable tension member to which are bonded hard Neoprene teeth. These teeth engaged in grooved pulleys providing a non-slip, non-stretch drive requiring neither lubrication or adjustment.

DRIVERLESS TRUCKS

The Western Region of British Railways is experimenting at Newton Abbot goods shed with two driverless trucks. Basically the guidance system operates by making the trolley follow a single wire laid just beneath the flooring and carrying an alternating current of about ½A of specified frequency.

Over a year ago, EMI Electronics, of Hayes, Middlesex, produced their driverless trolley system under the name of "Robotug." This the railways have adapted to use in association with the familiar battery platform trucks which have given good service over several years in their larger goods sheds. The trucks being used in the experiments at Newton Abbot are standard railway vehicles made by Scott Electric Vehicles Limited, of Kidderminster. That the battery capacity of 121 A hr was sufficient to enable work to be carried out for 8 hour shifts was established by a durability test in which a truck hauled a 3 ton load continuously for 3 miles at a steady speed of 2 m.p.h. Fitted to the front of each truck is a safety bumper so designed that, if an obstruction is met, a microswitch is actuated to de-energise the interlock relay and halt the truck. If required, the truck can be operated and driven in the usual way.

For the purpose of the experiment, nine tracks have been laid below the shed floor. The installation enables the yard staff to direct the driverless vehicle to any given point on the system.

ILLUMINATED ACOUSTIC CEILING PANELS

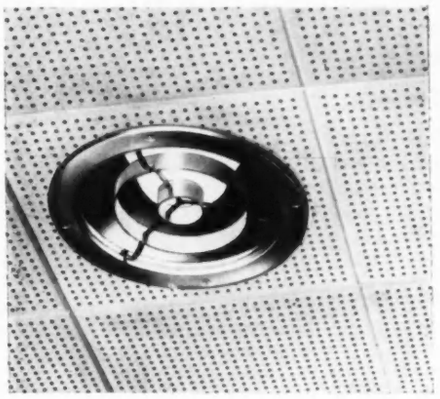
Inside illumination and sound absorption are combined in a new system known as the Siemens Ediswan Celotex illuminated acoustic ceiling, designed for good appearance, interchangeability, and ease of assembly and maintenance. Siemens Edison Swan Limited, 155 Charing Cross Road, London, WC2, and Celotex Limited, are providing a joint advisory service on acoustic and lighting problems.

The ceiling is made up of Celotex incombustible metal acoustic tiles perforated in a square pattern with holes large enough to prevent paint clogging. The units, 12 in by 24 in, are centre grooved to simulate two 12 in by 12 in tiles. Each tile is Bonderised for rust protection on both surfaces and all edges. Sound absorbing pads are placed into the metal tiles, separated from the tiles by a wire grid.

Lighting units are either fluorescent or tungsten. For fluorescent lighting, enamelled boxes containing 2 in or 4 in 40 watt tubes are placed above the ceiling and Perspex opal panels replace tiles at desired points. Alternatively, boxes housing filament lamps in spotlights or reflectors can be fitted.

Industries producing paint, chemicals, textiles, food and other products where colour rendering accuracy is important, have been provided with the well-known Siemens Ediswan hooded colour-matching unit for some years now. It provides as good an artificial daylight as can be obtained. The new illuminated acoustic ceiling presents the opportunity to make a further advance in the art of colour matching.

Compared with daylight, the light from a tungsten filament lamp is deficient at the blue



end of the spectrum. This deficiency can be corrected by combining the light from the tungsten lamp with that from a special blue fluorescent lamp. This feature can be incorporated in the Siemens Ediswan Celotex ceilings by using combinations of the same special blue fluorescent tubes and 60 watt pearl single coil gas filled filament lamps.

LARGE ROTARY DRIERS FOR FERTILISER PLANT

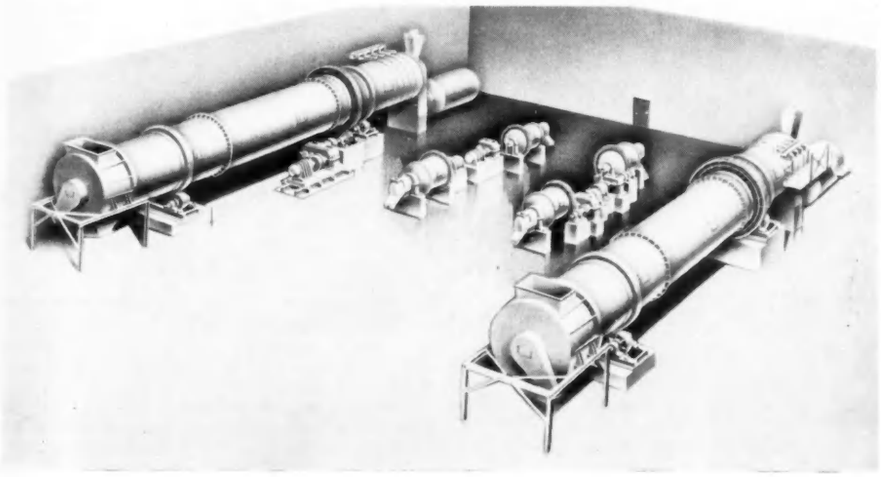
Two of the largest driers ever built have been supplied to ICI Limited, for the production of fertilisers, by Head Wrightson Stockton Forge Limited, a subsidiary of Head, Wrightson and Company Limited.

The driers are of the parallel flow single shell type, 12 ft in diameter by 90 ft long. They have a capacity of approximately 180 tons per hour and will be used in the production of fertilisers.

To ease transport and erection, and also to assist in the alignment of these driers, the shells were made in three pieces, the joints being machined with spigoted flanges, connected on site by fitted bolts. This method of manufacture greatly facilitated erection. The driers are provided with two heavy cast steel tyres mounted on machined cast steel chairs on the shell with girth rings of cast steel with machine cut teeth. The section rings are attached to inner carrier rings by fitted bolts. Both tyres and girth ring assemblies are mounted on heavy machined stiffening bands welded to the shells, and these bands were machined in one operation with the flanged and spigoted joint rings. Cast iron labyrinth seals are provided at the feed ends of the machines to prevent ingress of air and the leakage of material.

Powered by 300 h.p. squirrel cage motors through fluid couplings and totally enclosed helical reduction gear units, the drives are connected to the main countershafts which carry the forged steel pinions by flexible couplings. The bearing wheels are of cast steel running on Timken taper roller bearings on fixed spindles carried in heavy dead eyes on the bedplates. Similar construction is employed for the thrust wheels.

The roller bedplates are fabricated from steel sections and plates with machined pads to to accept the adjustable bearing wheel supporting dead eyes and the thrust plates are also made and machined to accommodate the cast steel thrust stands which carry the wheel spindles. As the material being handled is likely to become sticky under certain circumstances, "knockers" are provided near the feed ends of the shells to assist in preventing accumulations of material in this area. There are four pneumatically operated "knocker" units controlled by electrically driven rotary valve units, enabling the sequence and timing between units to be varied over a fairly wide range. Discharge of oversize material is achieved by radical lifters through a central cone outlet.



A.C. DYNAMIC BRAKING OF INDUCTION MOTORS

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DIRECT current dynamic braking of induction motors was discussed as long ago as 1910,[1] and is now well established for many types of drive, such as centrifuges, machine tools, lifts and mine winders.[2] In consequence considerable attention has been given to the prediction of its performance characteristics to obtain a correct choice of motor frame size and to increase the precision of the control design.[3] Compared with all other electrical methods of braking to standstill, it has the advantage of generating less heat in the motor,[4] and compared with reverse-current braking (commonly known as "plugging") in particular, it avoids the possibility of full-speed reversal.

The disadvantage of requiring a separate d.c. supply has for many years resulted in the application of various methods of a.c. dynamic braking particularly on the continent[5] and in America,[6] and recently in this country.[7] However, compared with d.c. braking, little attention has been given to the prediction of the performance characteristics of a.c. braking methods, other than plugging, and it is probable that this has delayed a more extensive and successful use of the methods. The object of the present article is to analyse one a.c. braking method which provides, in an economical manner, satisfactory characteristics for many applications.[8]

AUTO-TRANSFORMER CONTROL

Fig. 1 shows the usual connections of the supply lines to the motor and its control auto-transformer, with the unit operator[9] a (= 1·0/120°) being used in defining the balanced supply line voltages V, a^2V and aV. It will be seen that a varying degree of unbalanced voltage is applied to the motor by changing the auto-transformer tapping point connected to terminal B of the motor. In addition, it is usual to connect the motor terminal A to a fixed point on the auto-transformer which does not coincide with a supply-line connection. Hence, in order that the present analysis shall be quite general, both of the terminals A and B are considered to be connected to varying tapping points on the auto-transformer such that the potentials of terminals A and B are displaced from the line L3 potential by λaV and γaV, respectively, as shown in Fig. 2.

Unbalanced Voltages per Phase.—The following three independent and simultaneous equations of the unbalanced arrangement of Fig. 2 may be derived directly from Kirchoff's voltage law of a closed circuit.

$$V_1 = -\lambda aV - a^2V \quad . \quad . \quad (1)$$

$$V_2 = -V-(aV - \gamma aV) = (a^2 + a\gamma)V \quad . \quad . \quad . \quad (2)$$

$$V_3 = (\lambda - \gamma)aV \quad . \quad . \quad . \quad (3)$$

where V_1, V_2, V_3 represent the unbalanced phase voltages of the motor primary winding.

SEQUENCE-COMPONENT VOLTAGES

From the well-known symmetrical-component theory of three-phase systems[9], the positive-sequence and negative-sequence components of the unbalanced phase voltages are respectively V_p and V_n, where

$$3V_p = V_1 + aV_2 + a^2V_3$$

and

$$3V_n = V_1 + a^2V_2 + aV_3$$

Hence, using equations (1), (2) and (3) and simplifying

$$3V_p/V = (1 - a^2)(1 - \gamma - a\lambda) \quad . \quad (4)$$

and

$$3V_n/V = (1 - a)\,a\,(1 - \lambda - a\gamma) \quad . \quad (5)$$

Alternatively, if V_p, V_n and V represent the numerical r.m.s. values of the vector quantities V_p, V_n and V respectively, it may be deduced readily from equations (4) and (5) that

$$3(V_p/V)^2 = \lambda^2 + (1 - \gamma)^2 + (1 - \gamma)\lambda \quad (6)$$

and

$$3(V_n/V)^2 = \gamma^2 + (1 - \lambda)^2 + (1 - \lambda)\gamma \quad (7)$$

where λ and γ may be either greater or less than unity, and also may be either positive or negative values.

Thus, for given values of V, λ and γ the sequence-component voltages per phase can be readily evaluated; either as r.m.s. vector quantities using equations (4) and (5), or as r.m.s. scalar values using equations (6) and (7). It should be noted that no zero-sequence component of phase voltage V_0 exits, since $3V_0 = V_1 + V_2 + V_3 = 0$, by reference to Fig. 2.

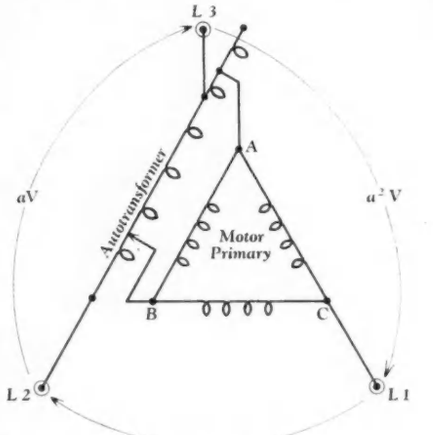


Fig. 1 Usual primary winding connections.

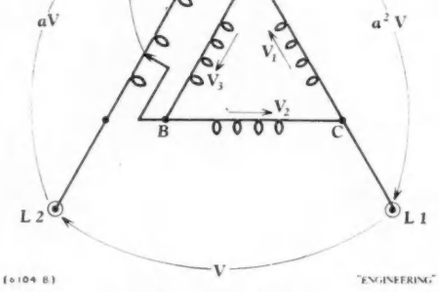


Fig. 2 General primary winding connections.

Sequence-Component Currents per Phase.—Having evaluated the sequence-component voltages per phase of V_p and V_n, the sequence-component currents per phase of I_p and I_n may be readily evaluated from the relationships

$$\left.\begin{aligned} I_p &= V_p Y_p \\ I_n &= V_n Y_n \end{aligned}\right\} \quad . \quad . \quad (8)$$

where Y_p and Y_n represent respectively the positive-sequence and negative-sequence admittances of the motor at any given fractional speed S of the rotor. Each sequence admittance may be calculated from its appropriate equivalent circuit of the motor, shown in Fig. 3.

Unbalanced Phase Currents.—When the sequence-component currents per phase I_p and I_n have been calculated from equation (8), the unbalanced phase currents are readily evaluated from the following well-known relationships of symmetrical-component theory.

$$\left.\begin{aligned} I_1 &= I_p + I_n \\ I_2 &= a^2I_p + aI_n \\ I_3 &= aI_p + a^2I_n \end{aligned}\right\} \quad . \quad . \quad (9)$$

Prediction of Torque-Speed Characteristics.—The net torque T developed at any given speed N is the difference between the sequence-component torques of T_p and T_n developed at speed N. That is,

$$T = T_p - T_n \quad . \quad . \quad (10)$$

Also, if T_{pn} and T_{nn} represent the torque for balanced operation of the three-phase motor with respectively a positive-sequence and a negative-sequence voltage equal to the rated or normal voltage V per phase, then

$$\left.\begin{aligned} T_p &= \delta(V_p/V)^2T_{pn} \\ \text{and} \quad T_n &= \delta(V_n/V)^2T_{nn} \end{aligned}\right\} \quad . \quad (11)$$

Evidently, T may be either a net motoring or braking torque, depending upon (i) the values of T_{pn} and T_{nn}, which are in turn dependent upon the value of rotor resistance, and (ii) the value of $(V_p/V)^2$ and $(V_n/V)^2$ as determined from equations (6) and (7), respectively.

For brevity, the torque-speed characteristic at the normal voltage V of positive sequence, plotted between the limits of forward and reverse synchronous speed for a given equivalent secondary resistance per phase of R_2, will be referred to as the normal curve. The values of T_{pn} and T_{nn} are provided by the normal curve between the limits of standstill and respectively the forward and reverse synchronous speeds. Thus, the normal curve, in conjunction with equations (6), (7), (10), (11), allows the T/N characteristic to be predicted for a given value of R_2.

Obviously, the normal curve may be determined from either the design data of the motor or by actual experiment for an available motor. The latter method is preferable since it takes account inherently of the effects of stray-load loss[11] and magnetic saturation; accurately in the case of balanced motor operation at normal voltage, and to a first approximation in determining T_p and T_n from equations (11) for un-

balanced motor operation. In general, the most significant effect due to magnetic saturation is that of a reduction of the leakage reactance of the machine with increased load current.

It is sufficient to determine the normal curve for the single condition of R_2 being the short-circuit value of R_{2s}, say. The normal curve corresponding to any greater value of R_2, equal to R_{2g} say (required in predicting the T/N characteristics for other notches on the controller), can be very simply derived from the normal curve corresponding to R_{2s}; it is merely necessary to increase the fractional slip in the ratio of R_{2g}/R_{2s} for any given value of T_{pn} or T_{nn}.

CONFIRMATION OF THEORY

In order to check the validity of the foregoing analysis, tests were performed on two 50 c/s induction motors, one a squirrel-cage machine rated at 3 h.p., 220V, 4 pole, and the other a slip-ring machine rated at 15 h.p., 400V, 6 pole; the former having negligible saturation effect but appreciable stray-load loss, and the latter having considerable saturation effect but negligible stray-load loss. Temperature effects were minimised by allowing each motor to run on no-load between successive steps in the tests, for a period of time sufficient to bring the stator winding resistance back to virtually its "cold" value, and also reducing the supply voltage so that the standstill current approximated to the rated value of the motor.

The torque-speed curves of both the to test motors have been predicted and obtained experimentally for a series of fixed values of both λ and γ (see Fig. 2). It is sufficient, for the present purpose, to consider the results obtained for the particular value of $\lambda = 0$ only, as shown in Figs. 4 and 5 for the squirrel-cage and slipring motors respectively. In both Figs. 4 and 5, the top-most curve is the normal curve as determined by experiment, whilst the remaining curves are for different degrees of unbalanced primary voltage as fixed by the value of γ. For brevity, the latter curves may be referred to as the unbalanced-voltage curves. In the case of the slipring motor, the results shown in Fig. 5 are for a value of external rotor resistance per phase which makes R_2 approximately equal to twice the total leakage reactance per phase corresponding to full-load operation.

It will be seen from Fig. 4 that the prediction of the unbalanced-voltage curves from the normal curve, using equation (10), is in good agreement with the experimental results. Thus, it may be concluded that the method of prediction takes into account adequately the effects of stray-load loss.

Referring to Fig. 5, it will be seen that the unbalanced-voltage curves predicted from the normal curve fail to give good agreement with the experimental results for the lower values of γ, corresponding to the lower values of load current. In consequence, the variation of the parameters of the equivalent circuit of the motor with load current were determined from short-circuit and open-circuit tests, and these showed the total leakage reactance of the slipring motor increases by 50 per cent when the load current decreases from 100 to 25 per cent of the full-load value. It was decided, therefore, to utilise the appropriately varying value of the leakage reactance in the equivalent circuit of Fig. 3 and then, using the values of V_p and V_n given by the respective equations (6) and (7), to determine the unbalanced-voltage curves from the relationship

$$T = 3I^2_{pr}R_2/(1 - S) - 3I^2_{nr}R_2/(1 + S) \quad (12)$$

where I_{pr} and I_{nr} are respectively the equivalent positive-sequence and negative-sequence rotor currents per phase, referred to the stator circuit. The results of the latter method are included in Fig. 5, and it will be seen that satisfactory agreement is obtained with the experimental results.

Examination of the design details of the slip-ring motor showed that an exceptionally low reluctance path to leakage flux existed at the tooth tips of its semi-closed slots and this results in excessive saturation of the teeth by the leakage flux for currents above about 50 per cent of the full-load value, to give the considerable variation in the leakage reactance noted in the preceding paragraph. Thus, it appeared likely that the use of a much reduced supply voltage in the present tests, to limit the standstill current for balanced operation to about 100 per cent of the full-load current, constituted the major

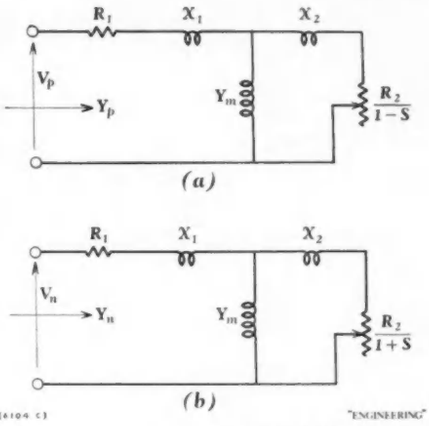


Fig. 3 Equivalent circuits—(a) positive sequence operation; (b) negative sequence operation.

reason for the unsatisfactory prediction of the unbalanced-voltage curves from the normal curve of Fig. 5; this being confirmed by subsequent test results at a higher supply voltage corresponding to a standstill current for balanced operation in excess of 200 per cent of the full-load current. That is, even in the case of a motor having considerable saturation effect, the prediction of the unbalanced-voltage torque-speed curves from the normal curve is in good agreement with the experimental results provided that the normal curve is obtained at a supply voltage not less than about 50 per cent of the rated voltage.

Referring to Figs. 1 and 5, it is of interest to note that whereas the normal connection of a slipring motor provides only one no-load speed, the addition of a single auto-transformer enables almost any no-load speed to be obtained, by varying the tapping points of the auto-transformer. The torque-speed curves obtained, and the simplicity of the arrangements, have resulted in a fairly wide application of the method to crane hoists in the United States.

Conclusions.—Symmetrical component theory can be readily used to predict with reasonable accuracy the torque-speed characteristics of the a.c. braking method which uses auto-transformer control, despite the presence of appreciable stray-load loss and varying degrees of magnetic saturation arising from the leakage flux of the motor.

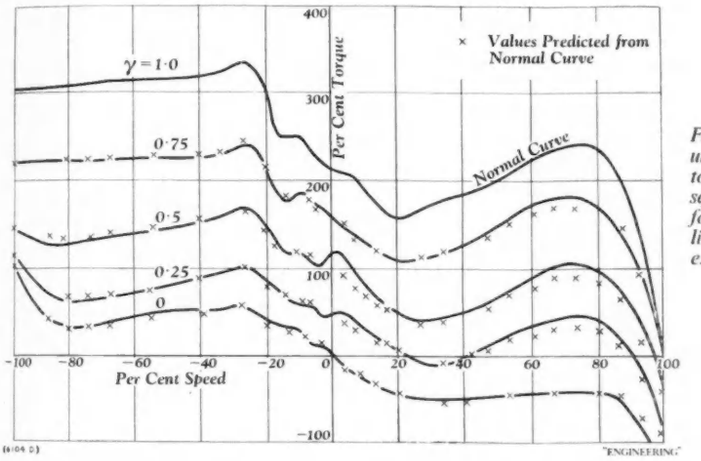
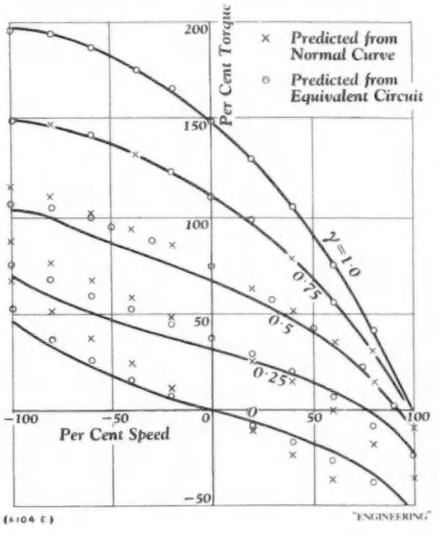


Fig. 4 Normal and unbalanced-voltage torque speed curves of squirrel cage motors for $\lambda = 0$. The full line curves are the experimental values.

Fig. 5 (below) Normal and unbalanced-voltage experimental torque/speed curves of slip-ring motor for $\lambda = 0$. The full-line curves are the experimental values.



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OFF-PEAK FLOOR HEATING FALLACIES

HEATING engineers who have hitherto been confined almost wholly to boiler-served systems are beginning to be concerned with off-peak floor heating projects using cables embedded in the floor screed so that heat continues to be emitted when electricity is switched off. Unfortunately several dangerous fallacies on this subject have become firmly established and drastic measures are now needed to uproot them.*

Some of the fallacies overdue for exposure are: (1) that switching off current for several hours in daytime does not require proportionate increase in loading; (2) that customary "off-peak" schedules do not cause overheating at night; (3) that room size, shape, exposure and partitions are of little importance compared with the thickness and weight of the outer wall; (4) that the so-called "self-regulating" property of a warm floor prevents appreciable variation in floor surface and room temperature and is always advantageous; (5) that a floor surface temperature of 75° F can provide full heating in living rooms and offices of normal construction and exposure; (6) that the value of heat stored in the ground under a solid floor warrants the omission of horizontal ground insulation; (7) that cables in a 2 in screed on ½ in insulation on hollow concrete beams can seriously be described as an "off-peak" system; (8) that carpets and down-to-floor furniture have negligible effect on performance—and on floor finishes; (9) that it is reasonable to expect tenants in skyscraper flats to pay by meter for the whole of their heat regardless of building construction, exposure and the characteristics of the heating system; (10) that outdoor temperature prior to 7 a.m. is a suitable index of heat requirements for the day commencing.

The eight-storey block of flats at Valley Gardens, Kirkcaldy, is an outstanding example of the way a fallacy can become firmly established. Off-peak floor heating, especially in the three-apartment flats, does not give tenants value for money and consumption of off-peak electricity is cut accordingly.

From the beginning each living room was provided with a 2 kW fire on normal supply at approximately ¾*d* per unit as well as off-peak floor heating at ½*d* per unit. Electricity for these fires and for lighting, cooking, etc., is supplied through the same meter. Electricity for local storage domestic hot-water immersion heaters as well as for floor heating is supplied through a single off-peak meter in each flat.

As shown in the accompanying illustration, the three-apartment living room has negligible partition storage in relation to heat loss. The use of thermal insulation below the screed makes the floor quite unsuitable for off-peak floor heating.

The sensible way to use the so-called "off-peak" floor heating in the three-apartment living rooms at Kirkcaldy is to switch on *only* during the afternoon when off-peak current is available for two or three hours and possibly for the two hours 7 p.m. to 9 p.m. if the weather is cold enough, but with discretion if the consumer has carpets which will operate to his own disadvantage and to the benefit of the tenant below. Doubtless many have already discovered these things from experience. Room thermostats would be most unsuitable here. Warning lights to remind tenants to switch off at 9 p.m. would be much more appropriate.

It is doubtful if floor heating in these living rooms is used enough to justify the cost of installation.

People in the two-apartment flats are much more fortunate. Their living room has only one exposed wall with a window of normal size. One of the partitions is 8 in thick "no-fines" concrete and floor area is only two-thirds that of the three-apartment living room (the hall has less than half), yet they have an installed heating load of 4·6 kW compared with 5 kW for the larger flat with three sides exposed, one of them largely glass from floor to ceiling, with door opening on to an external balcony in addition to a window of normal size in the long outer wall and potentially a much larger rate of air change.

Most of the people in these flats must be very pleased with the heating, and with good reason. They can have practically as much heat as they wish at less than 1*d* a unit, at any time it is likely to be of value, without bother, dirt, smell or draught. But this is no off-peak heating victory. Most tenants would now be amused if told that they were expected to leave the floor heating on room-'stat/time-switch control and to top up only when necessary with the 2 kW fires. They would *not* be amused if compelled to do without the fires.

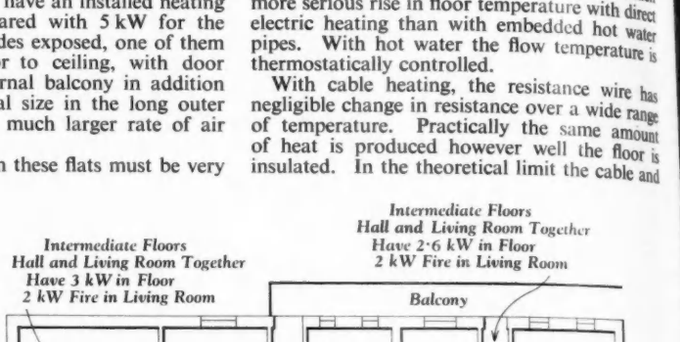
With floor heating the heat source is only a few degrees above room temperature so a small change in this difference affects the rate of heat transmission quite appreciably. As soon as current is switched off room temperature falls at a rate depending on indoor-outdoor temperature difference, and floor temperature falls at a rate depending on floor surface minus indoor temperature, the rate falling as the temperatures converge. Newton expressed this thought with old-fashioned clarity some time ago.

A carpet of given resistance causes a much more serious rise in floor temperature with direct electric heating than with embedded hot water pipes. With hot water the flow temperature is thermostatically controlled.

With cable heating, the resistance wire has negligible change in resistance over a wide range of temperature. Practically the same amount of heat is produced however well the floor is insulated. In the theoretical limit the cable and the insulated slab continue to rise in temperature until current is switched off.

Carpets have thus caused difficulties with floor finishes and rubber underlays; thermoplastic tiles have taken up the impression of the carpet or underfelt and wood block floors have suffered excessive shrinkage. The need for floor thermostats wherever carpets are likely to be placed, more conservative loadings, and/or a change of method is indicated.

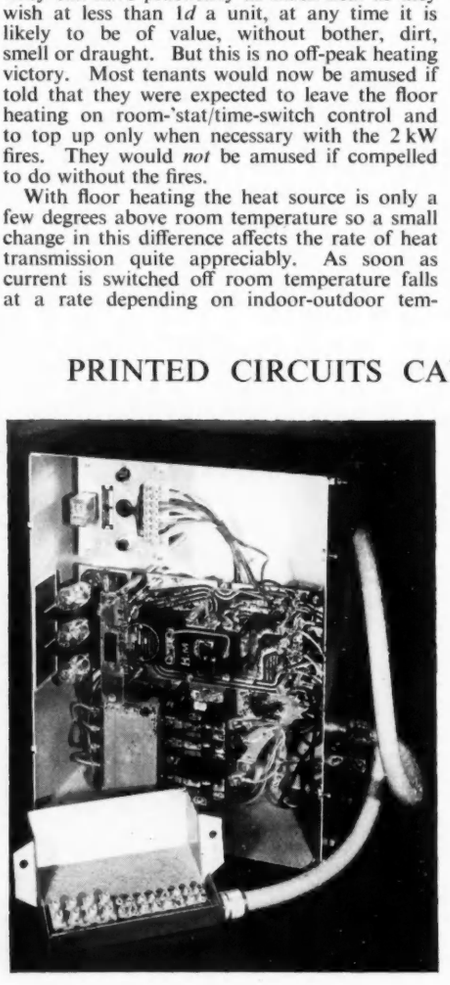
A new form of off-peak heating (still undergoing trials, and the subject of patent applications) promises substantial improvements in performance. There is obviously a great future for off-peak heating but it will not be improved by the reckless application of wishful thinking.



Typical flats in eight-storey block, Valley Gardens, Kirkcaldy. Outer walls of "no-fines" concrete 12 in thick. Heating cables in 2 in screed on ½ in thick glass-fibre insulation on 5 in thick hollow concrete pre-cast beams.

* Extracts from a paper given by Mr. H. H. Bruce, technical director of the Invisible Panel Warming Association, before the Institution of Heating and Ventilating Engineers on 4 March.

PRINTED CIRCUITS CARRYING 3 AMPERES



Control system for the MacFire oil-firing unit. It employs printed circuits which carry 3A.

One of the first major developments in the use of printed circuits outside the electronics industry is in the control system wiring of the new MacFire oil-firing units for boilers made by Urquharts (1926) Limited, Greenford, Middlesex. The technique of printed circuits is normally associated with micro currents, but in this case the Bakelite copper-clad laminate (grade P17416), which incorporates foil only 0·0015 in thick, carries current of up to 3 amps and also provides complete integration of the electrical components. This development is a pointer to the use of printed circuits for carrying heavier currents than hitherto, particularly as copper foil is readily available up to 0·0045 in thick which could, in many cases, carry current of 10A or more.

The etched wiring circuit was designed by Urquhart in conjunction with Printed Circuits Limited of Stirling Corner, Boreham Wood, Hertfordshire, a member of the LEW group of companies. The object of using such a circuit was to eliminate the complicated wiring and installation errors frequently associated with the control equipment of oil-firing units. Tracing of any faults that may occur is also considerably simplified.

Production

BULK HANDLING OF IRON ORE

Present Practice and Future Trends

As the scale of operations in the steel industry has grown, many problems have had to be solved to provide for the movement, storage and preparation of very large quantities of iron ore. The whole subject of ore transport, from the mines to the blast furnace stockyards, was surveyed at the recent meeting of the Iron and Steel Engineers' Group of the Iron and Steel Institute, held in the Netherlands—the first meeting of the Group, incidentally, to take place outside the United Kingdom.

Mr. C. R. Wheeler, President of the Iron and Steel Institute, who opened the meeting with a short survey of the world iron ore situation, said that until the middle of 1957 there was a world shortage of iron ore and that much work had been done in the 1950's to establish new sources of supply, and to extend existing ones, but this had given an assurance for the future. Long hauls by land and sea are necessary and the tendency in sea transport is to build very large special-purpose ships for carrying ore. Some differences of opinion exist as to the maximum size desirable, but deadweight tonnages of 100,000 or more have been discussed.

Such ore ships bring many advantages in operating costs, but they have their problems too, one being that very few ports can handle them. Consequently the question of ore transhipment is now having to be given serious consideration. British ore importing installations are not suitable for the very large ships of the near future, and transhipment may be necessary, either through a Continental port such as Rotterdam where suitable equipment is just being commissioned, or through a British port such as Milford Haven where the provision of facilities is under consideration.

Together with the equipment for handling very large vessels and for transhipment at central points to smaller craft comes a need for extensive stocking facilities, for some of the rapidly developing sources of supply, such as those in Labrador, are closed by ice for several months of the year. Such facilities may be hired at the ore transhipment points—this can be done at Rotterdam, for example—but attention is also being given to the matter at iron and steel works.

Finally, consideration has to be given to ore preparation on a much greater scale than hitherto. Many of the ores from new or expanding sources are too fine for direct use in the furnace or require concentrating before they can be used, and the present development of sintering and pelletising plants will, of necessity, be extended.

PREPARATION

Iron ores can be prepared for furnace use at the mine or quarry, at the transhipment plant or at the blast furnace plant—usually the work will be divided. At the mine some preliminary crushing may be necessary, and this will involve the provision of crushers which may have to be suitable for use underground-

Screening may be carried out at the mine, and if several grades of ore are produced, segregation, and, perhaps, blending to suit customers' requirements will be necessary. Mr. D. H. Sharp, in his paper "Ore-Handling Facilities at Seven Islands, Quebec," described an installation which operates from April to December each year and has a maximum capacity during the season of 12,400,000 long tons. Ore is crushed to 6 in cube at the opencast mines and sent in 87 ton rail wagons to the shipping terminal 360 miles away. Samples of ore are taken from the wagons as they are loaded at the mines and by the time the train arrives at the terminal a marshalling plan has been worked out for sorting the wagons to give the desired overall grade in the next ship to be loaded. Mechanical movement of the wagons into the classification yard and through the tipplers enables 8,000 tons per hour to be delivered to the conveyors feeding the ships.

SHIPPING AND UNLOADING

Ore is shipped in various types of vessel ranging from the special-purpose ore carrier to the general cargo ship, and, for inland transport, in motor barges. General cargo ships will probably continue to be used for ore transport, especially to the smaller ports, but it is on the large special-purpose vessels that interest is centred at present. These have, besides the economic advantage of size, which is of increasing importance on the long-haul runs of 2,000 miles or more, large, box-like holds, large hatches with maximum freedom from obstruction by masts or other deck structures, and have the propelling machinery and superstructure aft, so giving long clear runs over the deck and hatches for the loading and unloading equipment. The ships are so designed that most of the unloading can be done direct by the ore grabs, and a minimum of cleaning up by bulldozers lowered into the holds is necessary.

How large the special-purpose ore ships are likely to become is, at present, a matter of controversy. Dr. H. R. Mills, in his paper "The Unloading of Iron Ore Ships in the USA and Canada" said that nearly all American iron ore ports have deep water, and many large ore carriers up to 60,000 tons deadweight are in use. Ships of greater size have been considered by several nations, and even the figure of 150,000 tons has been spoken of as a possibility. Self-unloaders too, such as are used extensively for coal in North America, have been proposed for iron ore and there are, in fact, a few of these vessels so used, but their suitability for the purpose has yet to be proved.

One feature of the very large ore carrier, which was stressed by more than one speaker, is that the economic advantage, which increases rapidly at first in proportion to the size, does not continue to do so as the top limit is neared; if the operating costs are plotted against the tonnage, the curve, which rises sharply in favour of the large ship at first, shows a marked levelling off after about 30,000 tons. Towards the top limit the advantage is much less, and it may well be that even if some of the extremely large ships are built, the average size may settle around the 30/50,000 ton mark.

Two types of unloading installation are necessary; at the blast furnace plant, and at the transhipment point where the large ships are unloaded into the smaller ones or into barges. During the visit to the Netherlands, members of the Engineers' Group were able to inspect an installation of each type.

At the works of the Royal Netherlands Blast Furnaces and Steelworks, Ijmuiden, unloading facilities are provided for ocean-going vessels bringing ore from North and West Africa, Sweden, France, Spain, Canada and Brazil. The wharf, which is 1,100 ft long, takes vessels up to 15,000 tons. The unloading equipment comprises three 12½ ton bridge cranes capable of dealing with 200/240 tons/hr, one 15 ton level luffing crane of 240 tons/hr capacity, and two 25 ton level luffing cranes of 400 tons/hr capacity. Immediately behind the unloaders is the ore stockyard, and behind this the blast furnaces. Three reclaiming bridges span the stockyard and feed the blast furnace bunkers.

The second of the ore handling installations visited was designed for transhipment purposes. It is situated in the Botlek area of the Port of Rotterdam and is a joint venture of Wm. H. Muller and Company of Rotterdam, and the Hanna Mining Company of Clevelend, Ohio, USA. Both these companies have large interests in the shipment of ores to Europe, and the new Rotterdam installation, which was described by Mr. Fred D. Vines in his paper "The Muller-Hanna Ore Handling Installation at the Port of Rotterdam" before the visit took place, is designed to receive large ocean-going ore carriers, unload them and tranship the ore to smaller ships and Rhine barges. In addition a large storage area is available, complete with reclaiming plant, for stocking ore to allow for the closed season at the Labrador mines.

Phase 1 of the installation is now nearing completion. It will enable modern ships to be discharged at a rate of 1,300 tons/hr and will provide storage capacity for 1½ million tons. Large developments are planned in further phases up to a total of four. In the first phase there is a dock face of approximately 2,300 ft with two self-propelled unloaders, having rope-type grabs of 12 gross tons capacity. Each machine will deal with an average of 650 tons/hr of iron ore weighing 135 lb/cu. ft when discharging a modern ore carrier of 15,000 tons capacity or larger. The "free-digging" capacity of the unloaders is in excess of 1,000 tons/hr.

Ore lifted by the unloaders from the ships is discharged to a hopper in the unloader structure and taken by a dock-face belt conveyor to a storage area from which a reclaiming bridge recovers it as required. Alternatively, the unloaders can deposit the ore on an adjacent "short storage" area behind and reclaim it themselves.

On the same dock face as the unloaders is a boom-type loader which takes its feed from the dock-face conveyor, and loads ships or barges as required. With the Muller-Hanna plant it is possible to unload large vessels and load smaller ones simultaneously, to load into and out of stock as required, and to segregate ores which are the property of different customers so that they can be reclaimed as required.

HANDLING ASHORE

Some works, such as those at Ijmuiden, the Margam Works of the Steel Company of Wales or the East Moors Works, Cardiff, of the Guest Keen Iron and Steel Company are at the dock side, and the unloaders can deposit the ore straight into the blast furnace stockyards or to a short conveyor leading to the stocking point. In Britain this advantage is often countered to some extent by the shallow approaches to the dock which make it impossible to deal with very large ships. Margam, described in a paper by Mr. J. E. Robson, and East Moors, described by Mr. T. Jenkins, both have some limitations in the matter of ship sizes.

Other British and Continental works are at some distance from the ore handling port, and rail or barge transport (the latter only being used where a large waterway such as the Rhine is available) are necessary. In the case of rail transport, several special installations have been provided by British Railways to meet the requirements of individual blast furnace plants, and as Mr. T. V. Nicholson showed in his paper "Transportation and Handling of Iron Ores in Great Britain" some 19 million tons of ore are railborne every year; rather more than half this quantity is home produced. In Great Britain the tendency is for the traffic to be handled in special large wagons such as the 56 ton side door type used at Consett, but many smaller side tippler wagons are also in use.

The overall effect of modern developments is that handling is now so closely integrated with the production processes that the handling engineer and the production manager are each finding it increasingly necessary to know at least the rudiments of the other's job.

FIRST SET FOR HIGH MARNHAM

200 MW Turbo Alternator Completed

The first 200 MW 3,000 r.p.m. reheat steam turbine for the British Central Electricity Generating Board has now successfully undergone tests at the English Electric works preparatory to being installed in High Marnham power station.

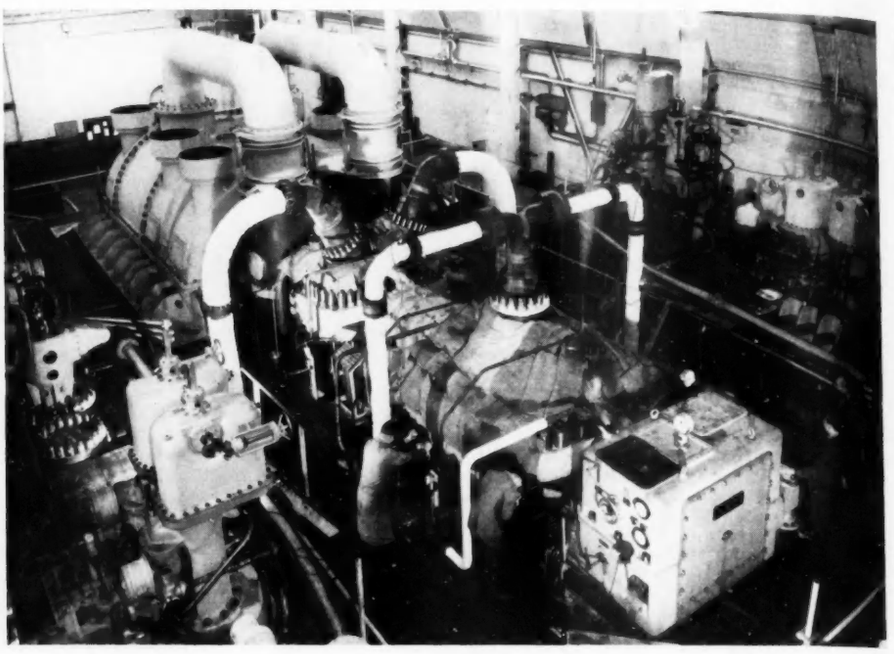
High Marnham is in an agricultural belt in the East Midlands on the west bank of the River Trent. It is within easy access of the East Midlands coalfields and close to the main railway line linking Chesterfield and Mansfield with Lincoln. When completed, the station will contain five 200 MW sets and will be the largest, not only in Britain, but also in Europe. The new turbine is the first tandem 200 MW unit to be manufactured in Britain.

At High Marnham the five turbo-alternator units to be are arranged in line along the station at 120 ft centres. The total weight of one turbo-alternator unit is 1,450 tons, the maximum lift being that of the alternator stator at 168 tons approximately.

With a running speed of 3,000 r.p.m., the turbine is of the horizontal three-cylinder design having a double casing impulse type high-pressure cylinder. Steam enters the turbine stop valve at 2,350 lb per sq. in and 1,050° F. The steam from the high-pressure turbine exhaust is taken to the reheater and then returned to the intermediate-pressure cylinder at 475 lb per sq. in and 1,000° F. The intermediate-pressure cylinder is combined with one section of the three-flow low-pressure cylinder and has impulse stages up to the point of exhaust to the low-pressure stages.

Approximately one-third of the steam remaining after bleeding passes through the combined low-pressure portion, and the remaining two-thirds is led through two overhead interconnecting pipes to the double-flow, low-pressure cylinder. The three-flow low-pressure cylinder exhausts to a single-shell condenser, rated for 28·7 in Hg.

The condensing plant includes a single-shell condenser, two full-duty extraction pumps, three 50 per cent duty rotary Leblanc type main air pumps and two quick-starting exhausters. There is a six-stage feed water system giving a maximum temperature of 460° F at continuous maximum rating. Feed water deaeration is supplied with provision for off-load deaeration.



A 200 MW set has completed its works tests.

The alternator is hydrogen cooled employing direct cooling of the stator and rotor conductors at a rated gas pressure of 30 lb per sq. in. The hydrogen coolers are arranged longitudinally in the upper part of the stator frame, and circulation of the hydrogen through the machine and coolers is by means of an axial flow blower. Generation is at 16,500 V with rated phase current of 7,780 A at 0·9 power factor.

The exciters comprise a main and pilot unit arranged back to back on the same shaft and driven through gearing from the tail end of the alternator. They are totally enclosed and ventilated on the closed circuit principle, the air being circulated through the machines and coolers by means of a direct coupled fan. The maximum output of the main exciter is 3,000 A at a rated voltage of 520 V, the speed of the exciters being 750 r.p.m.

MORE GAS FOR THE MIDLANDS

A further step in the modernisation and extension plan of the West Midlands Gas Board has been taken with the recent completion of the Walsall Gas Works. Gas has been made on the present site since 1877, the works having been enlarged and re-equipped until, at the time when the Board took over, the plant was capable of producing 4 million cu. ft of gas per day in vertical retorts and 750,000 cu. ft per day in a carburetted water gas plant. Plans had been made for a considerable increase in output, and the Board decided to develop the site to its maximum capacity by erecting two vertical retort houses and a carburetted water gas plant giving an overall gas making capacity of 18 million cu. ft per day.

Effective use of a sloping site is one of several special features of the reconstructed Walsall Gas Works. All liquids produced flow by gravity to the treatment plant.

The reconstructed works, with Woodhall-Duckham carbonising plant, carburetted water gas equipment by Humphreys and Glasgow, and W. C. Holmes purifiers, follows in general the standard practice for modern gas works. It does, however, possess some features of special interest, at least one of which had to be adopted because of shortage of materials of construction at the time of building.

When construction of the tower purifiers commenced in 1953-54, there was a shortage of structural steel, and as a consequence the crane gantry was designed for building in reinforced concrete. The structure, 80 ft high, and carrying a 50 ton crane, is of distinctive and pleasing appearance. It will, of course, have considerable advantages in the matter of maintenance.

Because the site slopes down from the canal which forms one boundary, to the railway which marks the opposite limit of the works, construction of the plant was not easy. It was complicated, too, by the fact that the existing retort house and ancillary equipment had to be kept in operation until sufficient new plant was built to take its place. In one respect, however, the natural change in level has proved advantageous, the fall of about 30 ft having been used for the movement of the liquid materials.

Coal is received principally by rail (provision is made for dealing with lorry-borne coal if necessary), and from the sidings it is taken by a very extensive system of belt conveyors to the

Operation and Maintenance

400 TON FLOATING CRANE FOR MARACAIBO

A 400 ton diesel-electric floating crane has been towed 4,700 miles to the Lake Maracaibo oilfields from Amsterdam for use by Compania Shell de Venezuela. The crane is the first of its type to be built in Europe.

Called the "Atlas," the unit will speed up oil gaining operations since it will transport a complete drilling floor and derrick, including derrick floor, all floor equipment and drill pipe racked in the derrick, from one foundation to another. The rigging up and down of the derrick and other equipment will no longer be necessary.

With this new mover it will also be possible to shift, in two lifts, a complete block station of two large holding tanks, six oil and gas separators and up to six pipeline delivery pumps. This will eliminate the present system whereby these lake installations are fabricated on land, then partially dismantled and moved to the lake location for re-erection.

The mover consists of a 130 ft by 72 ft barge on which is mounted an A-type crane capable of a 400 ton lift. Both jibs will have two lifting tackles, each having a lifting capacity of 120 tons, which may be used independently or in any combination. Four tackles, each taking a load of 24 tons, will control the movement of the load sideways. The crane winches are powered by 110 h.p. electric motors fed by d.c. generators driven by diesels. A single operator will handle the entire system from a control panel.

"Atlas" will be able to move a complete drilling floor and derrick.

Built jointly by Gusto, Schiedam, and Verschure of Amsterdam, the crane was towed out by the Dutch tug Barendsz-zee.

SEAL OF SAFETY

A scheme for independent examination of equipment from a safety point of view has been introduced by the British Safety Council, 60 Westbourne Grove, London, W2. A manufacturer submits a product for testing, which is carried out by selected independent laboratories, and if the product meets the high standards of safety set by the Council it is awarded a certificate and seal of approval. Periodical tests will be carried out by the Council on products purchased in the open market, thus ensuring that the required standards are maintained.

Concluding

More Gas for the Midlands

retort houses near the top of the site, or to the adjacent stocking ground, which will hold 28,000 tons, or sufficient for 6½ weeks of normal operation. Although this arrangement means that the coal has to be conveyed uphill, it has the advantage that the liquids produced, which are much more difficult to move by power, gravitate to the by-product storage wells and treatment plant at the lower end of the works.

All internal transport of coal and coke is by conveyor, some 14,000 ft or 2½ miles having been installed for this purpose. Reversible drives allow material to be transferred from one section of the plant to another in either direction as required, and to be crossed from one normal direction of travel to another. A mimic diagram in one of the retort houses enables the setting of the conveyors to be seen at any time.

Now that the plant is complete and in normal operation it has been possible to compare production figures based on manpower with those of the old works. An increase in potential production of 280 per cent has been achieved with a total increase in labour of only 85·2 per cent; such is the value of modern plant.

Steel was in short supply when the tower purifier crane gantry was built, so reinforced concrete was used for this 80 ft high structure.

Marketing

Cooperative Exports

The development of competition between nations for the world's markets is dictating a change in the pattern of British exports and in the methods used by British exporters. More and more firms, particularly in the engineering industries—even the largest—are finding the task of competing with national corporations or with government-assisted exporters beyond their own resources. Increasingly, therefore, rival firms in Britain are tending to come together and present a united front to their foreign competitors. A good case for such united action, under a national banner, was put to members of the Royal Society of Arts recently by Mr. Julian Tritton, speaking on behalf of British consulting engineers. Another example of this trend was provided by the Steels group of companies. Their chairman, Mr. James Steel, announced that Steels had purchased R. H. Neal and Company Limited, and F. Taylor and Sons (Manchester) Limited, in order to strengthen the bid of British mobile crane makers (Steels Engineering Products make the Coles diesel-electric crane) in overseas markets.

The latest example of two companies joining forces in export markets is provided by Tube Investments and Raleigh Industries, who have formed a jointly-owned company to coordinate their cycle manufacturing activities in the Republic of Ireland. In this case they were seeking "increased economy and efficiency" in a market where each had manufacturing subsidiaries. The two companies announced that this may be the forerunner of similar agreements in other export countries, particularly where their manufacturing and assembly plants are under-employed.

TI and Raleigh stated most emphatically that joint action overseas did not mean a lessening of competition between them in the United Kingdom. There is no reason why it should. Powerful arguments can be advanced for similar joint action on the part of other engineering firms, and by firms in other major export industries.

Dollar Appeal

Exports to the dollar area were up by 3 per cent last year in spite of a fall in the total of British exports, according to an article in the Treasury's *Bulletin for Industry*. The dollar market is in three main parts, with the United States taking a half, Canada one-third and Latin America one-seventh, of United Kingdom sales. The bulk of the increase to the USA was in cars, where there was considerable competition from Germany, France and Italy. Exports of aircraft were up 154 per cent on the previous year largely because of sales of turboprop airliners. General engineering showed some gains but electrical machinery sales were down.

The rise in British exports to the USA continues a trend that has brought the dollar market up from sixth place in 1948 to first place today. There are two main reasons for this development. Firstly, US total demand has increased rapidly. In 1948 imports of manufactured and semi-manufactured goods were only $25 a head, while the national income averaged $1,510 a head. Secondly, British exporters have been helped by the fact that manufactures now represent a much higher proportion of total American imports. In 1948 they represented only 19 per cent of imports. Last year's figure was 31 per cent.

The incentive to export to the USA in the years of the dollar shortage, and the fine work of the Dollar Exports Council have produced an intensive drive by British manufacturers. The composition of the UK exports list has changed considerably over the last ten years. The most striking change has been the increase in cars from 10 per cent of exports in 1948 to nearly 35 per cent in 1958; and of aircraft and parts from 0·5 per cent to 13·1 per cent. Apart

from these two items, and, of course, whisky, the increases in British exports have been mainly in capital goods. In this section competition is warming up as the Japanese are coming into the market as well as the Germans, Italians and French.

But although competition is getting keener, the market's potentialities remain enormous. Even during the 1957-58 recession, the sharpest experienced by America since the war, imports of manufactured goods continued to go up.

Leipzig Forum

Every year in every way the Leipzig Fair gets better and better. At least this is the keynote of the statement put out by the East German Chamber of Foreign Trade. This fair is the shop window of Germany's other half and this year Mr. Khrushchev himself came and looked in. The number of western countries doing business there at government, bank or trade association level goes up every year. The visits to India, Iraq and the United Arab Republic made by Prime Minister Grotewohl last year have borne fruit in long-term agreements made at the fair. The fall in world prices of foodstuffs and raw materials has left many of the underdeveloped countries short of foreign currency. The East German no-deposit barter terms, which the statement calls "bilateral balanced trade," have more than usual appeal. Some imports are being increased by the East Germans with a view to raising consumption standards at home and creating a market for their exports. The main increases are in coffee, cocoa and tropical fruits.

Trade with the United Kingdom has been increased by the agreement made between the Federation of British Industries and its East German opposite number for trade to the value of £7 million. The main items will be exports of machinery from Britain. Any increases in imports agreed to by East Germany are on the understanding that they will be matched at the other end. The idea is that balance of payments problems are avoided if trade is balanced.

Handling Exports

The growing complexity in the handling of overseas contracts and the emphasis on "service" has led the General Electric Company Limited to form a new company to handle overseas contracts. The main object is to make the company's wide range of experience more readily available to overseas customers and generally to give better service. This may include preliminary survey and planning work as well as the actual installation of plant and equipment.

The new company, GEC Overseas Services Limited, will operate as main or sub-contractors and are prepared to work with civil and electrical contractors, mechanical engineers or others on complete "turnkey" contracts or on specific projects. Complete airfield electrification, lighting schemes, and the entire electrification of buildings are typical of the projects they will handle, as well as work in the engineering and telecommunications fields. They may operate anywhere overseas, as occasion demands. It is yet another step towards matching the fully integrated applications engineering service provided by several of the German and American firms, and by the state agencies of Soviet bloc countries.

At Home

PIPED WATER SUPPLIES

World Record

Opening the Duston Mill Works of the Mid-Northamptonshire Water Board on Friday, 17 April, Mr. Henry Brooke, Minister of Housing and Local Government, said "Everybody who has not got a piped water supply wants one. Everyone who has got one takes it for granted. . . . I am proud to say that more than 95 per cent of all households throughout England and Wales have piped water. No other country in the world can rival that figure. I am determined to see it creep up ever nearer to 100 per cent."

The Minister further commented that in many areas up and down the country the demand for piped water has doubled itself in the last ten years. This has been largely due to the building of new houses, converting of old houses and the installation of many new baths and washing machines. Mr. Brooke also pointed out that the demands are still increasing and that steps are being taken "to see that water is ready to meet this swift uprush of demand" by regrouping the water undertakers to form larger and stronger units.

"Water undertakers were first urged to get ahead with regrouping in the autumn of 1956. There were then 1,026 separate undertakings in England and Wales. There are now 951. A reduction of 75 in two and a half years may seem small, but a good deal of this work has taken place in the first three months of this year, and from the work in hand I judge that this accelerating pace will continue and that in the near future we are going to make a big advance towards larger and stronger units," said Mr. Brooke.

Taking a look at the statistics for gas and electricity supplied to households in England and Wales, we see that the percentages come to 93 per cent for households supplied with mains electricity and just under 75 per cent for households supplied with mains gas.

OIL-FIRED BOILER FOR THE SMALL HOME

A new oil-fired boiler, specially designed for the smaller home, and having a maximum output of 12,000 Btu's per hour, is now being marketed by Glow-worm Boilers Limited, 47 Hatton Garden, London, EC1. It will provide for normal hot water requirements and, if required, it will also take two or three panel radiators.

The Oil-Crat, as it is called, will not only provide hot water but will in addition heat the kitchen. Both manual and thermostatically controlled models are available. The manual model has a six position control knob operating from a high flame down to a pilot flame, at which setting only one tenth of a pint of oil per hour is consumed. Ordinary domestic vaporising oil is recommended, the cost of which is about 1*s* 6*d* per gallon on average.

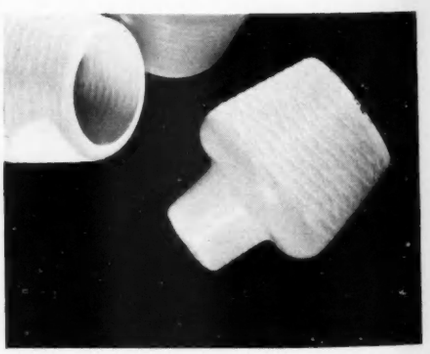
The cost of the thermostat model is £42, which is marginally greater than the manually controlled model. Installation is said to cost slightly more than for a solid fuel burner. A front thermometer is included and there is also a built-in draught diverter.

UNBREAKABLE PLASTICS LAMPSHADES

Translucent lampshades which are rigid, lightweight, and virtually unbreakable have just been introduced by H. W. Field and Son Limited, Harold Wood, Essex. Made from a new high density polyethylene, they will resist cracking or breaking under the most stringent conditions and can withstand temperatures up to 120° C.

These lampshades, which are marketed under the trade name Fildenex, are formed into an attractive shape, with a good surface finish, by a blowing process similar to that used in blowing glass bottles. They are obtainable in five colours; opal white, pink, yellow, green and blue and can be used for single or multi-pendant fittings or for wall bracket fittings.

Due to the properties of the high density polyethylene from which they are made, they are suitable for lamps of up to 100 watts.



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